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5 Plaintiff In Pro Per

6 **UNITED STATES DISTRICT COURT**

7 **CENTRAL DISTRICT OF CALIFORNIA-WESTERN DIVISION**

8 JOSEF MAATUK,

9 PLAINTIFF

10 v.

11 EMERSON ELECTRIC, INC., THERM-O-
12 DISC, BERND ZIMMERMAN, PRASAD
13 KHADKIKAR, AND DOES 1-100/
14 INCLUSIVE,

15 DEFENDANTS

16 CASE NO:

17 **CV 16-06177 GHK(JPR)**

18 COMPLAINT FOR

- 19 1. RECOGNITION AS CO-INVENTOR
20 AND CORRECTION OF
21 INVENTORSHIP PURSUANT TO 35
22 USC § 256
23 2. MISAPPROPRIATION OF TRADE
24 SECRET
25 3. UNJUST ENRICHMENT

26 **JURISDICTION AND VENUE**

27 Venue is proper in this district, pursuant to 28 USC § 1391, because a substantial part of the
28 events and omissions giving rise to the Plaintiff's claims happened in this district.

Furthermore, some of the acts committed by Thermodysc which give rise to the causes of action
in this case were committed in the Central District of California.

2. This Court has jurisdiction over this matter pursuant to 28 U.S.C. 1331, 1332, 1338, and 1367
because this action arises under Title 35 of the USC, this controversy involves citizens of
different states, and the amount in controversy exceeds the sum of \$75,000, and all the claims

COMPLAINT

1 are so related as to form part of the same case or controversy under Article III of the U.S.
2 Constitution.

- 3 3. This Court also has original jurisdiction over this matter, because this matter involves a matter
4 of who are the correct matters related to a patent, and the U.S. District Courts have original
5 jurisdiction over such matters under 35 USC.

6 The events and omissions giving rise to the Plaintiff's claims include, but are not limited to, the
7 research efforts conducted by Dr. Josef Maatuk, and the records of this research, that led to Dr.
8 Maatuk's discovery of elements of the invention described in some of the claims of Patent
9 #7,775,105.
10

11 Dr. Maatuk gave information about elements of the invention described in some of the claims
12 of patent #7,775,105 to Therm-O-Disc, pursuant to a confidentiality agreement, which limited
13 the uses to which Therm-O-Disc could put the information given to Therm-O-Disc by Dr.
14 Maatuk. Therm-O-Disc later filed a patent application, application no. 11/587,325, listing Dr.
15 Bernd Zimmerman, and Dr. Prasad Khadkikar, employees of Therm-O-Disc, as the inventor.
16 Dr. Maatuk contends that he was a co-inventor of patent #7,775,105. The research conducted
17 by Dr. Maatuk, and the records of this research, are located in this judicial district.
18

- 19 4. The fact that Therm-o-Disc and Emerson Electric are large business entities with hundreds of
20 millions or billions of dollars in revenue, while Dr. Maatuk is an individual with limited means,
21 means that Therm-O-Disc and Emerson Electric have more resources to spend on litigation in
22 general than Dr. Maatuk. The disparity of resources between the parties is an additional reason
23 why the Central District of California is an appropriate place for venue of this lawsuit.
24

25 The acts complained of herein with reference to the "trade secret misappropriation" cause of
26 action happened between 2010 and 2016, therefore they are within the statute of limitations for
27 that cause of action. The acts complained of herein with relation to co-inventorship and
28

1 correction of inventorship happened with reference to patent #7,775,105, which is still valid
2 and non-expired, and at any time during the life of a patent an omitted inventor may sue for
3 correction of inventorship, and to be included as an inventor of the patent. See 35 USC § 256,
4 which states that a co-inventor of the subject matter of an issued patent may be added to the
5 patent as an inventor by a court before which such matter is called into question. See also
6 *Ethicon, Inc. v. United States Surgical Corporation*, 135 F.3d 1456 (Fed. Cir. 1998).
7

- 8 5. A co-inventor who has not been listed as an inventor on the patent should have right to assert
9 an interest sufficient to support standing in litigation, both for the co-inventor's benefit and in
10 the public interest of assuring correct inventorship designations on patents. *Chou v. University*
11 *of Chicago* 254 F.3d 1347 (Fed. Cir. 2001). The potential for recognition, the ability to
12 practice the invention, and loss of licensing revenue, are also sufficient reasons to create
13 standing for the omitted co-inventor, in this case Dr. Maatuk.
14

15
16
17 **PARTIES**

- 18 6. Dr. Josef Maatuk is an individual, holding a doctorate in mechanical engineering, and doing
19 business under the name Max Em Engineering, in the Central District of California, offering,
20 among other services, consulting and research services. Dr. Maatuk is resident in the Central
21 District of California.
22
23 7. Emerson Electric is a corporation, doing substantial business nationwide, including substantial
24 business in the Central District of California.
25
26 8. Therm-o-Disc is a wholly owned subsidiary of Emerson Electric, doing substantial business
27 nationwide, including substantial business in the Central District of California. Thermo-o-Disc
28

1 also specifically contacted Dr. Josef Maatuk for advice concerning certain liquid probes, while
2 knowing that Dr. Maatuk was based in the Central District of California.

- 3 9. Dr. Prasad Khadkikar is an individual residing in Ohio, who corresponded directly with Dr.
4 Maatuk concerning the subject matter that was later incorporated into Patent #7,775,105. Dr.
5 Khadkikar is also an employee of Therm-O-Disc, and was an employee of Therm-O-Disc at the
6 time that he made this correspondence, and also at the time that he made the application for
7 Patent #7,775,105. Dr. Khadkikar is listed as one of the two co-inventors of Patent #7,775,105.
8
9 10. Dr. Bernd Zimmerman is an individual residing in Ohio, who corresponded directly with Dr.
10 Maatuk concerning the subject matter that was later incorporated into Patent #7,775,105. Dr.
11 Zimmerman is also an employee of Therm-O-Disc, and was an employee of Therm-O-Disc at
12 the time that he made this correspondence, and also at the time that he made the application for
13 Patent #7,775,105. Dr. Zimmerman is listed as one of the two co-inventors of Patent
14 #7,775,105.
15
16 11. The application for Patent #7,775,105 was filed on April 21st, 2005, and published on August
17 17th, 2010. Patent applications are not available to the public before they are published, and so
18 Dr. Maatuk could not have known about the application for Patent #7,775,105, or about the
19 misappropriation for trade secrets contained therein, before August 17th, 2010.
20
21 12. Dr. Maatuk is informed and believes that each of the Doe Defendants was acting as the agent,
22 servant, or employee of the other defendants. Dr. Maatuk will amend this complaint when the
23 true names and capacities of the Doe Defendants becomes known.
24
25 13. Dr. Maatuk is informed and believes, and thereon alleges, that at all relevant times mentioned
26 herein, each of the Defendants was acting as the agent, servant and employee of each of the
27 remaining Defendants and, in doing the things herein alleged, was acting within the course and
28 scope of such agency and employment.

1 14. There presently exists, and at all relevant times herein mentioned there did exist, a unity of
2 interests and ownership between Defendants, such that an individuality and separateness
3 between each of them has ceased and Defendants are the alter-egos of each other.

4 15. All the Defendants cooperated in creating the wrongs which happened to Dr. Maatuk, and all
5 Defendants profited from these wrongs. In particular, Therm-O-Disc is a wholly owned
6 subsidiary of Emerson Electric, therefore Emerson Electric profited from the wrongs
7 committed by Therm-O-Disc. Furthermore, Dr. Zimmerman worked for Therm-O-Disc, and
8 was listed as an inventor on a patent assigned to Therm-O-Disc on which Dr. Maatuk is an
9 omitted co-inventor, therefore Dr. Zimmerman participated in the wrongs committed by
10 Therm-O-Disc against Dr. Maatuk, and Therm-O-Disc participated in the wrongs committed by
11 Dr. Zimmerman against Dr. Maatuk.
12

13 16. Adherence to the fiction of separate existence of Defendants as entities distinct and separate
14 from the other Defendants would permit an abuse of the corporate and/or limited partnership
15 privilege and would promote injustice in that Defendants would avoid their debts, obligations
16 and liabilities, and would sanction fraud or otherwise aid in the consummation of a wrong of
17 which the facts and allegations are set forth throughout the remainder of this Complaint and
18 incorporated for all purposes herein as fully set forth.
19
20

21 **FACTS AND ALLEGATIONS**
22

23 17. In or about December 1997, Therm-O-Disc engaged Max-Em Engineering for discussions
24 concerning liquid sensors related to automotive technology and automotive fuel tank sensing.

25 18. Therm-O-Disc also began evaluation of certain liquid sensors created by Maatuk, for the
26 purpose of possibly manufacturing said sensors. A copy of the confidentiality agreement
27 signed by Maatuk and authorized representatives of Therm-O-Disc is included as Exhibit B.
28

1 The confidentiality agreement says that confidential information given from Dr. Maatuk to
2 Therm-O-Disc shall be used solely for the purposes of evaluating Dr. Maatuk's liquid sensor
3 technology for potential license to Therm-O-Disc.

4 19. The confidentiality agreement between Dr. Maatuk and Therm-O-Disc also stated that
5 information about the design, construction, testing, or manufacturing of any Max-Em product
6 would be considered confidential information.

7
8 20. Pursuant to the agreements, Dr. Maatuk sent Therm-O-Disc a sample of the probe. He also
9 explained various ways that the probe can be made. A copy of a letter discussing this is
10 attached as Exhibit C.

11 21. Dr. Zimmerman identified critical variables of the probe. Ex. D. Dr. Maatuk later explained
12 how the sensor that the parties were discussing should be configured to fulfill these variables.
13 Ex. E.

14
15 22. In a letter to Dr. Khadkikar of Therm-O-Disc, in 1998, Dr. Maatuk discussed additional
16 characteristics that a marketable sensing probe should have, and the ways that the probe could
17 achieve these characteristics. Ex. F.

18 23. The technology and "know-how" that Dr. Maatuk provided to Therm-O-Disc, pursuant to Dr.
19 Maatuk's confidentiality agreement with Therm-O-Disc, included information about how to
20 properly shape the heater of a sensor, in terms of shaping the ratio of surface area to cross-
21 section, and also controlling the distance between the thermocouple junctions to give a desired
22 transient and steady-state heat profile on the heater. This allowed a customer to get continuous
23 or discrete level-reading. Dr. Maatuk also explained how to eliminate the non-random errors of
24 the probe or the electronic hardware, and reducing the random error amplitude.

25
26 24. Dr. Maatuk also explained how to determine the liquid parameters, discrete liquid levels, and
27 kind of liquid, within a short time.
28

1 25. When Therm-O-Disc's personnel did not know how to improve the reading from the
2 thermocouples, which were part of the sensors in question, Dr. Maatuk advised them to use an
3 algorithm that he had already given them, and scale the reading over four thermocouples, to get
4 an accurate reading of the liquid level. See Exhibit G.

5 26. Dr. Maatuk developed the following additional points that he disclosed to Therm-O-Disc. Dr.
6 Maatuk disclosed these points to Dr. Khadkikar and Mr. Zimmermann during a long
7 correspondence between them. This correspondence happened between 1997 and 2000, and
8 related primarily to Therm-O-Disc considering a liquid level sensor developed by Dr. Maatuk
9 for licensing. Dr. Maatuk also told Dr. Khadkikar and Mr. Zimmermann about how to solve
10 various problems related to the liquid level sensor, connected to specific applications of the
11 sensor. The information Dr. Maatuk disclosed to Dr. Khadkikar and Mr. Zimmermann
12 included, but was not limited to:
13

- 14 A. How to get the desired temperature and voltage profile along the probe via proper selection
15 of the width and cross-section of the separate heater or the heater that is also a common
16 wire.
17
18 B. How to get desired accuracy for the self-calibrated reading via proper selection of the
19 location of the location of the temperature junctions.
20
21 C. Explaining that this self-calibrated reading can be done for a probe temperature or
22 inflection point associated with determining the liquid level, or other profiles for the liquid
23 level.
24
25 D. The idea of producing the probe heater, and/or the copper traces, and/or the coating with
26 production methods of the following types: Vacuum deposition, molding, lamination, and
27 screen printing. Dr. Maatuk also noted that the selected production method needs to
28 minimize heat losses from the probe if low power is used, or higher power can be used to

1 achieve desired accuracy while simplifying the electronic hardware and software regarding
2 the noise effects in the profile voltage or temperature reading of the probe.

3 E. Dr. Maatuk presented to Therm-O-Disc the idea of filtering the sloshing via mechanical
4 tubes or software.

5 F. Dr. Maatuk presented to Therm-O-Disc the idea of using different nominal voltages or
6 temperature profiles for the probe to increase the reading accuracy.

7
8 G. Dr. Maatuk presented to Therm-O-Disc the use of conductive polymer with the same
9 electronic hardware for liquid level measurement, to measure acidity of liquids.

10 H. Dr. Maatuk explained to Therm-O-Disc how to use the normalized voltage or temperature
11 profile to achieve accurate level reading while reducing the response time of a sensor,
12 which consists of the probe, electronic hardware, and software. Dr. Maatuk also
13 demonstrated how to heat and cool the probe so that the random error of the probe reading
14 would be minimized faster.

15
16 I. Dr. Maatuk explained to Drs. Khadkikar and Zimmerman the construction and design of a
17 multi-function sensor comprising: a fluid level sensor module; a turbidity sensor module; a
18 temperature sensor module; and a pressure sensor module; wherein the temperature sensor
19 module comprises a temperature dependent, variable resistor; and the pressure sensor
20 module comprises a first electric circuit comprising a first thermocouple junction and a
21 second thermocouple junction, said second thermocouple junction located in a spaced
22 relationship from said first thermocouple junction; and a second electric circuit comprising
23 a heat source for raising the temperature of said first thermocouple junction above an
24 ambient temperature.

25
26 J. Dr. Maatuk explained to Drs. Khadkikar and Zimmerman the construction and design of a
27 multi-function sensor comprising: a fluid level sensor module; and a turbidity sensor
28

1 module; wherein the fluid level sensor module comprises: a first electric circuit comprising
2 a first thermocouple junction and a second thermocouple junction, said second
3 thermocouple junction located in a spaced relationship from said first thermocouple
4 junction; and a second electric circuit comprising a heat source for raising the temperature
5 of said first thermocouple junction above an ambient temperature.

6
7 K. Dr. Maatuk explained to Drs. Khadkikar and Zimmerman the construction and design of a
8 fluid level sensor module that includes a first electric circuit comprising: a plurality of first
9 thermocouples provided in longitudinally spaced relationship; and a plurality of second
10 thermocouples provided in longitudinally spaced relationship, respective ones of said
11 plurality of second thermocouples being positioned in laterally spaced relationship to
12 respective ones of said plurality of first thermocouples, said first and second thermocouples
13 being electrically connected in an alternating series relationship; and a second electric
14 circuit comprising: a heat source for raising the temperature of each of said plurality of first
15 thermocouples above an ambient temperature.

16
17 L. Dr. Maatuk explained to Drs. Khadkikar and Zimmerman the construction and design of a
18 first thermocouple junction and a second thermocouple junction disposed on a substrate,
19 said second thermocouple junction located in a spaced relationship from said first
20 thermocouple junction along a first axis; a second electric circuit comprising a heat source
21 disposed on said substrate for raising the temperature of said first thermocouple junction
22 above an ambient temperature; a light source located at one end of said substrate; and a
23 photosensor paired with said light source; and wherein said sensor is adapted to generate at
24 least one signal indicative of each of the level of a liquid within a vessel and the turbidity of
25 said liquid within said vessel.
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1 M. Dr. Maatuk explained to Drs. Khadkikar and Zimmerman the construction and design of a
2 fluid flow rate sensor module; a turbidity sensor module; a temperature sensor module; and
3 a pressure sensor module; wherein the temperature sensor module comprises a
4 thermocouple junction and the pressure sensor module comprises a thermocouple junction.

5 27. 35 USC § 116, states that Co-inventors may apply for a patent jointly even though (1) they did
6 not physically work together or at the same time, (2) each did not make the same type or
7 amount of contribution, or (3) each did not make a contribution to the subject matter of every
8 claim of the patent. To be considered a co-inventor, each inventor must only do part of the act
9 necessary to make the invention. A contribution to one claim of the invention is enough for the
10 inventor to be considered a co-inventor of the entire patent. SmithKline Diagnostics, Inc. v.
11 Helena Lab. Corp., 859 F.2d 878 (Fed. Cir. 1988).

12 28. Dr. Maatuk and Dr. Zimmerman were collaborators with reference to the invention of patent #,
13 and Dr. Maatuk contributed subject matter to the claims of patent #7,775,105, so Dr. Maatuk is
14 a co-inventor of patent #7,775,105.

15 THE PREVIOUS CASE

16 29. There was a previous case between the parties (case 1:2000-cv-02105 in the Northern District
17 of Ohio), which was a declaratory judgment action filed by Therm-O-Disc with relation to two
18 other patents (U.S. Pats. 5,730,026 and 5,908,985). However, that case involved different
19 subject matter from this present case, and therefore, res judicata and collateral estoppel do not
20 apply to this present case. Furthermore, this case concerns U.S. Pat. 7,775,105, filed in 2005,
21 the application for which was published in 2010. Case 1:2000-cv-02105 was decided in 2002.
22 Dr. Maatuk could not have known that Therm-O-Disc would apply for Patent no. 7,775,105
23 until 2010, so the matter of Dr. Maatuk's con-inventorship of the invention of Patent no.
24 7,775,105 could not have been resolved in case 1:2000-cv-02105.

1 30. The issue of misappropriation of the trade secrets discussed herein could not have been
2 resolved in case 1:2000-cv-02105 because Dr. Maatuk could not have been aware of Therm-O-
3 Disc's misappropriation of the trade secrets discussed herein at a time when case 1:2000-cv-
4 02105 was pending. Case 1:2000-cv-02105 was ended during 2002. Therm-O-Disc began
5 making use of the trade secrets discussed herein during 2003 or 2004, thus the misappropriation
6 that is the subject of this present case began in 2003 or 2004. Dr. Maatuk could not have
7 become aware of this misappropriation until August 17th, 2010.

8 **FIRST CAUSE OF ACTION-CORRECTION OF INVENTORSHIP UNDER 35 USC §**

9 **256**

10 **(AGAINST ALL DEFENDANTS)**

- 11 31. Dr. Maatuk incorporates all previous paragraphs by reference as though fully set out herein.
- 12 32. An omitted co-inventor may sue in federal court for correction of inventorship, regarding the
- 13 relevant patent, under 35 USC § 256.
- 14 33. Dr. Maatuk contributed non-obvious limitations to numerous claims of Patent 7,775,105, so he
- 15 is a co-inventor of the invention of Patent 7,775,105. Among other contributions that Dr.
- 16 Maatuk made, Dr. Maatuk explained to Dr. Khadkikar and Mr. Zimmermann how to build the
- 17 devices of Claims 1 and 2 of Patent 7,775,105, the first and second electric circuits of Claim 5
- 18 of Patent 7,775,105, the multifunctional sensor listed in Claim 8, the multifunctional sensor
- 19 listed in Claim 9 of Patent 7,775,105, and the multifunctional sensor listed in Claim 12 of
- 20 Patent 7,775,105.
- 21 34. Dr. Maatuk made these contributions as part of a collaborative research effort with Dr.
- 22 Khadkikar and Mr. Zimmermann of Therm-O-Disc to create functional, efficient, and accurate
- 23 liquid sensing probes.
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1 35. Dr. Maatuk was damaged by the fact that he was not listed as a co-inventor of Patent 7,775,105
2 when the application for this patent was filed. The loss of potential for recognition, the loss of
3 ability to practice the invention, and loss of licensing revenue, and also the loss of the ability to
4 “swear back” the invention of Patent 7,775,105 as a reference with relation to rejections under
5 35 USC § 103, relating to other patent applications, and loss of the ability to claim continuity
6 from the application for Patent 7,775,105 to other patent applications, are all ways in which Dr.
7 Maatuk was damaged by Defendants’ legally unsound decision not to list Dr. Maatuk as a co-
8 inventor of the invention of Patent 7,775,105.
9

10 36. Dr. Maatuk is entitled to have Patent 7,775,105 corrected to list Dr. Maatuk as an inventor of
11 this patent.

12 37. Dr. Khadkikar and Mr. Zimmermann were listed as the inventors on Patent 7,775,105 and did
13 not include Dr. Maatuk as an inventor, even though they knew that they had corresponded with
14 Dr. Maatuk, and some of the claims in Patent 7,775,105 were based on the information
15 disclosed to Dr. Khadkikar and Mr. Zimmermann by Dr. Maatuk. Therefore, Dr. Khadkikar
16 and Mr. Zimmermann are defendants with relation to this cause of action.
17
18

19 **SECOND CAUSE OF ACTION-MISAPPROPRIATION OF TRADE SECRET**

20 **(AGAINST ALL DEFENDANTS)**

21
22 38. Dr. Maatuk incorporates all previous paragraphs by reference as though fully set out herein.

23 39. The information that Dr. Maatuk gave to Therm-O-Disc, including, but not limited to, the
24 information listed in ¶26 of this complaint, was secret information, not generally known to the
25 public or in the public domain, that was used in Dr. Maatuk’s field of business for constructing
26 more efficient and effective sensors, that gave economic advantage to the person with
27
28

1 knowledge of it. The economic advantage came from the ability to obtain profit through sale of
2 more efficient and effective sensors.

3 40. Dr. Maatuk took reasonable steps to maintain the secrecy of the secret information that he gave
4 to Therm-O-Disc. These steps included, but were limited to, labeling this information as secret
5 and/or confidential, and causing Therm-O-Disc to sign a confidentiality agreement.
6 Furthermore, the information that Dr. Maatuk gave to Therm-O-Disc was known by both
7 parties to be not publicly available, and would be considered confidential by general
8 implication. *E.g., Sandlin v. Johnson*, 152 F.2d 8, 11 (8th Cir.1945) (licensing
9 arrangement); *see also Burten v. Milton Bradley Co.*, 763 F.2d 461, 463 (1st Cir.1985) ("Where
10 the facts demonstrate that a disclosure was made in order to promote a specific relationship the
11 parties will be bound to receive the information in confidence.").

12
13 41. Therm-O-Disc breached the confidentiality agreement between itself and Dr. Maatuk by
14 disclosing the information in ¶26 to third parties, and therefore misappropriated Dr. Maatuk's
15 trade secrets. Therm-O-Disc also misappropriated Dr. Maatuk's trade secrets by including the
16 technology described in the items K-M of ¶26 in the application for Patent #7,775,105, thus
17 Thermodisc tried to claim for itself the trade secrets described in items K-M of ¶26 in the
18 application for Patent #7,775,105, and so Thermodisc misappropriated these trade secrets from
19 Dr. Maatuk.
20
21

22 42. Dr. Maatuk was damaged by the fact that Therm-O-Disc misappropriated Dr. Maatuk's
23 aforementioned trade secrets. The loss of licensing revenue and sales revenue were also
24 additional losses to Dr. Maatuk, from Therm-O-Disc's misappropriation of Dr. Maatuk's trade
25 secrets.
26

27 43. Ds. Khadkikar and Mr. Zimmermann participated substantially in the theft of Dr. Maatuk's
28 trade secrets, and were in fact the people who conveyed these trade secrets to the rest of Therm-

1 O-Disc management. Dr. Khadkikar and Mr. Zimmermann are therefore defendants with
2 relation to this cause of action.

3 44. The amount of such damages will be proven at trial, but will be at least \$500,000.
4

5 **THIRD CAUSE OF ACTION-UNJUST ENRICHMENT**

6 **(AGAINST ALL THERM-O-DISC AND EMERSON ELECTRIC)**

7 45. Dr. Maatuk incorporates all previous paragraphs by reference as though fully set out herein.
8

9 46. If Therm-O-Disc is allowed to continue profiting from the information that Dr. Maatuk
10 disclosed to it, which Therm-O-Disc did not compensate Dr. Maatuk for, then Therm-O-Disc
11 will be unjustly enriched, because it will have received a benefit (Sales revenue from the
12 technology disclosed by Dr. Maatuk, and increased ability to control the market in relevant
13 sensor technologies via its control of Patent #7,775,105 which is based on the technology
14 disclosed by Dr. Maatuk) which Therm-O-Disc did not pay for. Dr. Maatuk, however, will
15 suffer a detriment to Therm-O-Disc because he will not be compensated for the valuable
16 technology that he has developed and shown to Therm-O-Disc.
17

18 47. It would be unfair for Therm-O-Disc to keep the aforementioned benefits without paying Dr.
19 Maatuk for them.

20 48. Therm-O-Disc would therefore be unjustly enriched if it were permitted to keep the
21 aforementioned benefits without paying Dr. Maatuk for them.
22

23 49. The value of these benefits will be proven at trial, but will be at least \$500,000.
24

25 **PRAYER FOR RELIEF**

26 **DR. MAATUK RESPECTFULLY REQUESTS:**

27 **ON THE FIRST CAUSE OF ACTION**

28 1. Patent #7,775,105 be corrected to list Dr. Maatuk as a co-inventor of said patent.

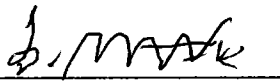
2. Dr. Maatuk recover his costs, including any attorney's fees that he incurs pursuant to 35 USC § 285, from Defendants
3. Dr. Maatuk recover such other relief from Defendants as the Court should deem to be fair and equitable.

ON THE SECOND CAUSE OF ACTION

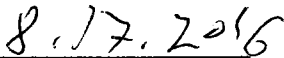
1. Compensatory damages in an amount to be decided by the Court, but no less than \$500,000.
2. Dr. Maatuk recover his costs, including any attorney's fees that he incurs pursuant to 35 USC § 285, from Defendants
3. Dr. Maatuk recover such other relief from Defendants as the Court should deem to be fair and equitable.

ON THE THIRD CAUSE OF ACTION

1. Compensatory damages in an amount to be decided by the Court, but no less than \$500,000.
2. Dr. Maatuk recover his costs, including any attorney's fees that he incurs pursuant to 35 USC § 285, from Defendants
3. Dr. Maatuk recover such other relief from Defendants as the Court should deem to be fair and equitable.



Josef Maatuk



Date

EXHIBIT A



US007775105B2

(12) **United States Patent**
Khadkikar et al.

(10) **Patent No.:** **US 7,775,105 B2**
(45) **Date of Patent:** **Aug. 17, 2010**

(54) **MULTI-FUNCTION SENSOR**

(75) Inventors: **Prasad Khadkikar**, West Chester, OH (US); **Bernd D. Zimmermann**, Ashland, OH (US)

(73) Assignee: **Therm-O-Disc, Incorporated**, Mansfield, OH (US)

(*) Notice: Subject to any disclaimer, the term of this patent is extended or adjusted under 35 U.S.C. 154(b) by 696 days.

4,785,665 A	11/1988	McCulloch	
5,831,159 A	11/1998	Renger	
6,134,952 A	10/2000	Garver et al.	
6,595,049 B1	7/2003	Maginnis, Jr. et al.	
7,146,991 B2 *	12/2006	Stockert	134/57 R
7,534,304 B2 *	5/2009	Conrad et al.	134/10
2002/0032532 A1	3/2002	Babel et al.	
2003/0117623 A1	6/2003	Tokhtuev et al.	
2004/0117919 A1 *	6/2004	Conrad et al.	8/137
2004/0139555 A1 *	7/2004	Conrad et al.	8/137
2005/0091755 A1 *	5/2005	Conrad et al.	8/137
2005/0091756 A1 *	5/2005	Wright et al.	8/137

(21) Appl. No.: **11/587,325**

(22) PCT Filed: **Apr. 21, 2005**

(86) PCT No.: **PCT/US2005/013662**

§ 371 (c)(1),
(2), (4) Date: **Jul. 12, 2007**

(87) PCT Pub. No.: **WO2005/106403**

PCT Pub. Date: **Nov. 10, 2005**

(65) **Prior Publication Data**

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(52) U.S. Cl. **73/290 R; 73/655**

(58) Field of Classification Search **73/290 R, 73/655**

See application file for complete search history.

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Primary Examiner—Hezron Williams

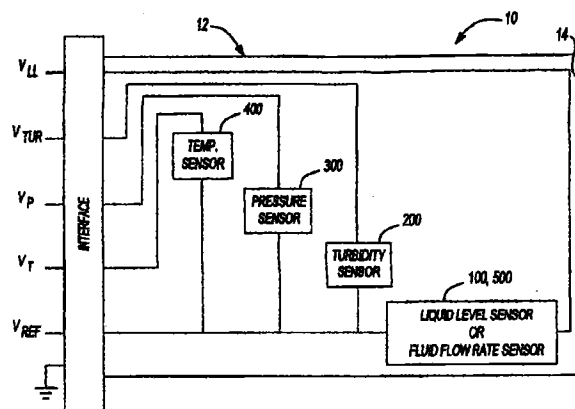
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(57) **ABSTRACT**

A multi-function sensor is disclosed which provides a reliable and simple device for accurately measuring and/or monitoring the ambient conditions within a container or the like, such as the level of a fluid, the turbidity of a fluid, the temperature of a fluid or surrounding environment and the ambient pressure. The sensor incorporates a fluid level sensor module, a turbidity sensor module, a temperature sensor module and a pressure sensor module. The fluid level sensor module utilizes a plurality of thermocouple junctions grouped in pairs with the pairs being spaced along a line extending generally in the direction in which the liquid level may vary. The thermocouple junctions are connected in series and produce a signal indicative of the level of liquid along the sensor. A turbidity sensor module is also integrally included on the multi-function sensor. Additionally, temperature and pressure sensor modules may also be incorporated in the multi-function sensor. Alternatively, a fluid flow rate sensor module may be included in place of the liquid level sensor module.

22 Claims, 9 Drawing Sheets



U.S. Patent

Aug. 17, 2010

Sheet 1 of 9

US 7,775,105 B2

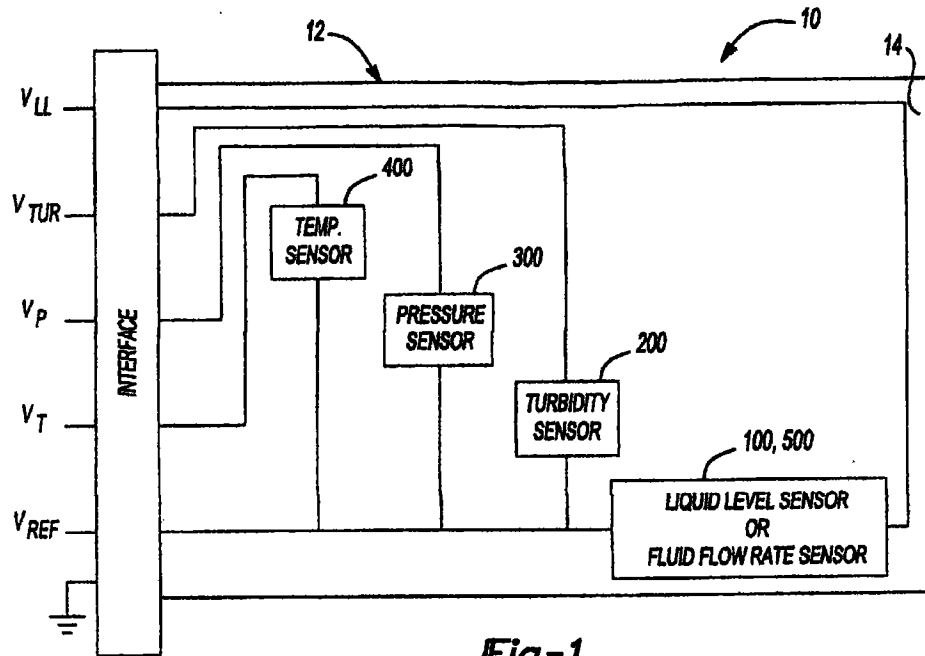


Fig-1

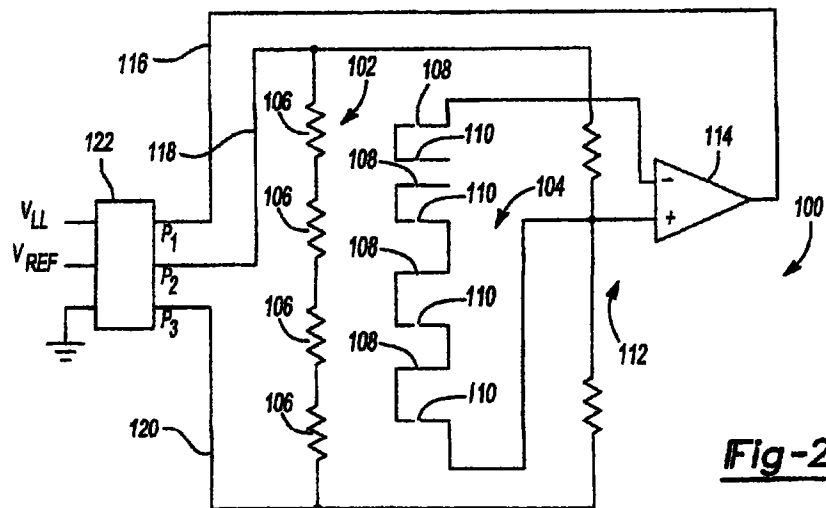
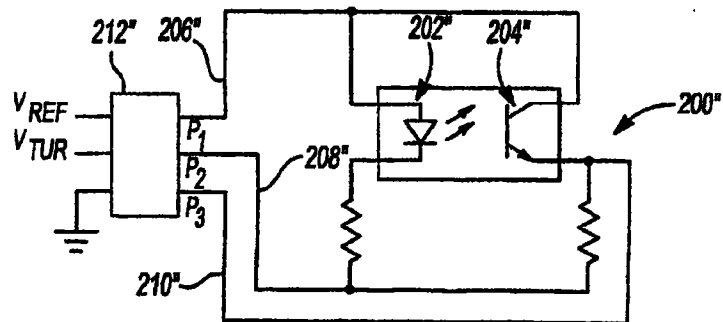
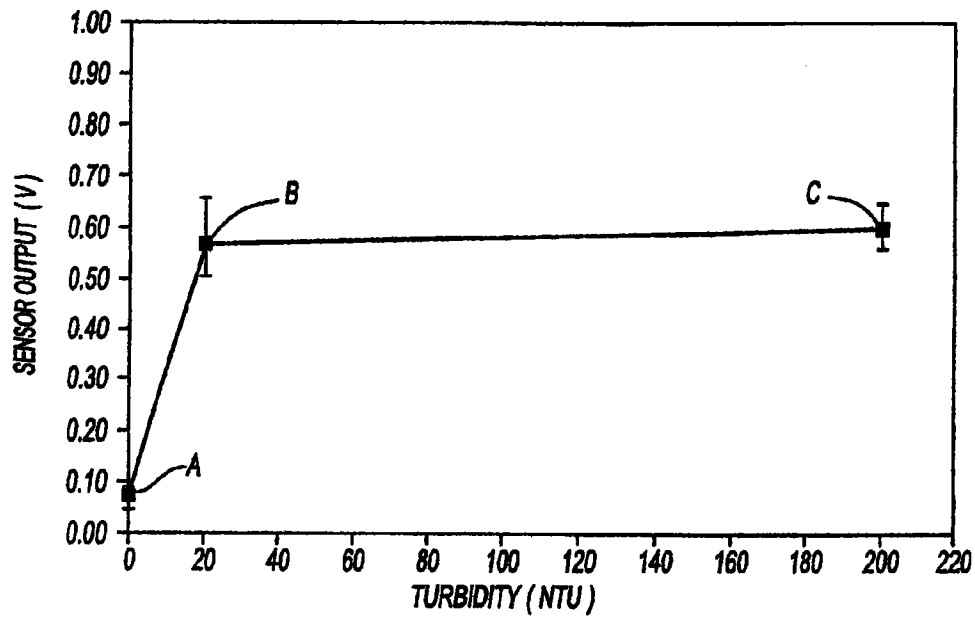
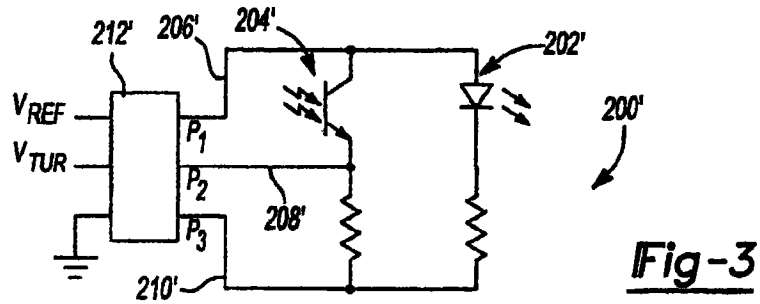


Fig-2

U.S. Patent

Aug. 17, 2010

Sheet 2 of 9

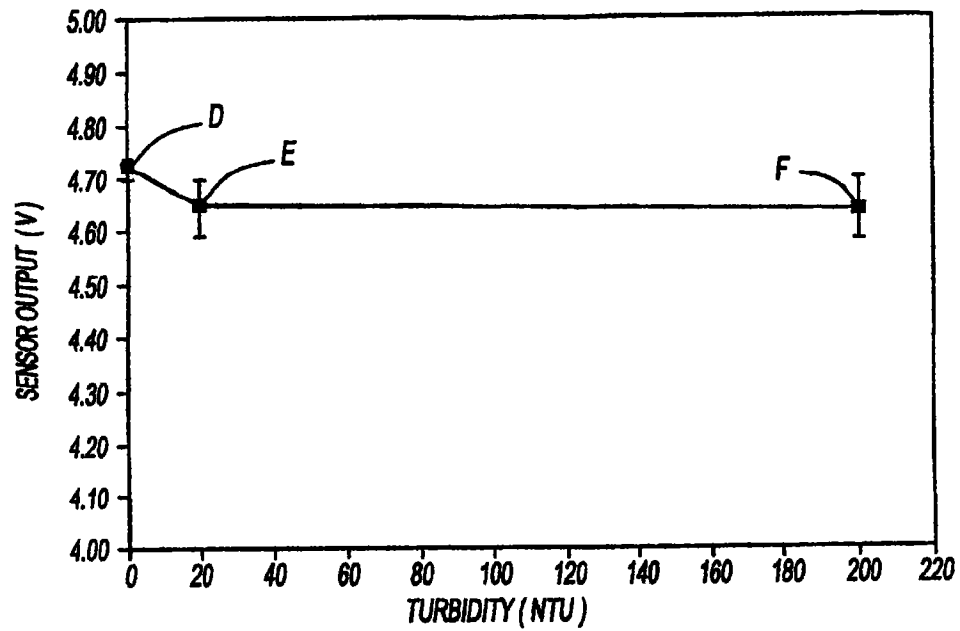
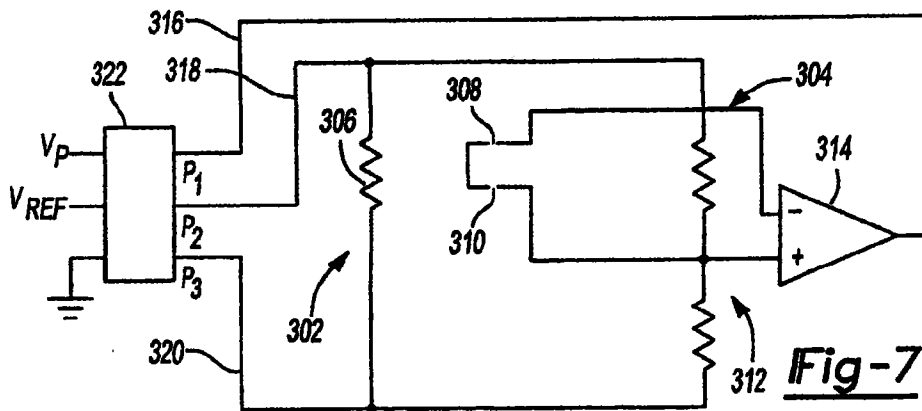
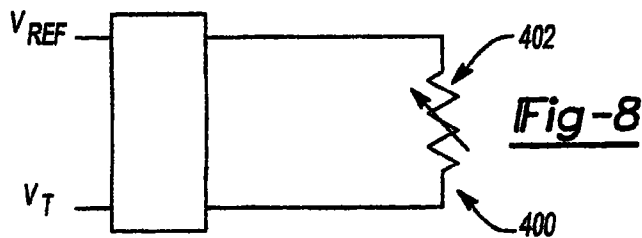
US 7,775,105 B2

U.S. Patent

Aug. 17, 2010

Sheet 3 of 9

US 7,775,105 B2

Fig-6Fig-7Fig-8

U.S. Patent

Aug. 17, 2010

Sheet 4 of 9

US 7,775,105 B2

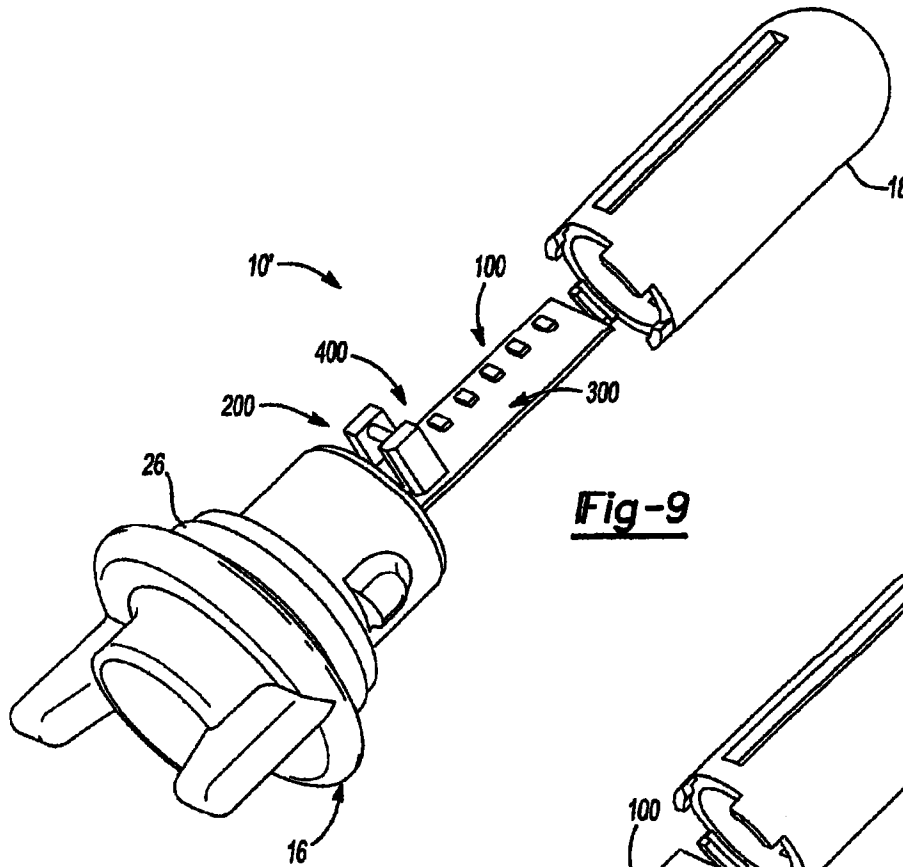


Fig-9

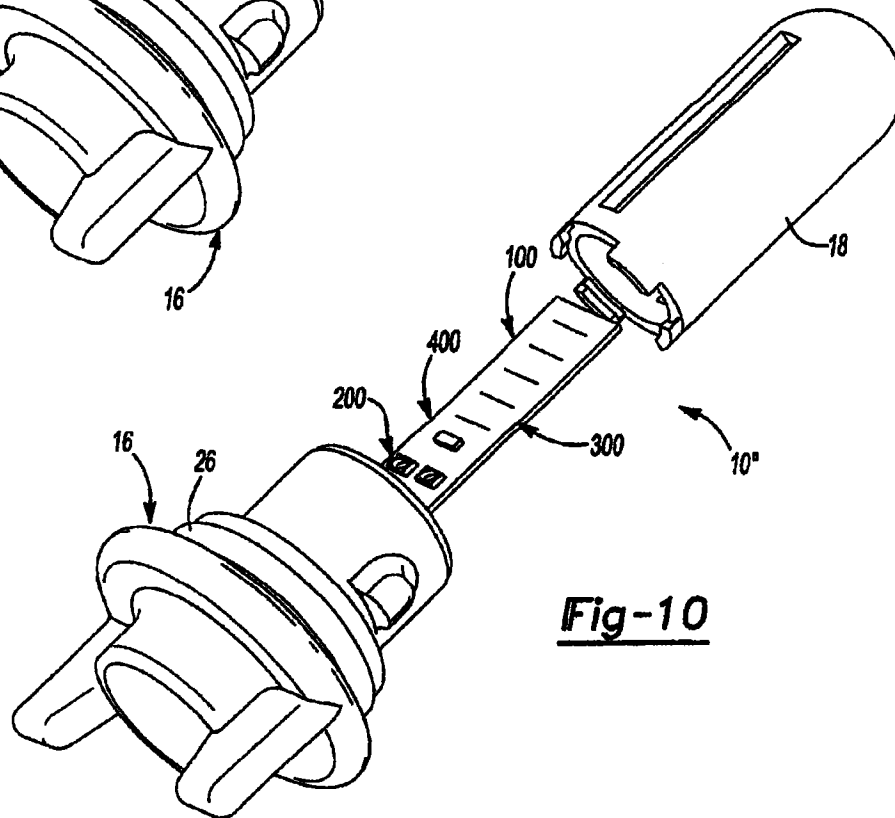


Fig-10

U.S. Patent

Aug. 17, 2010

Sheet 5 of 9

US 7,775,105 B2

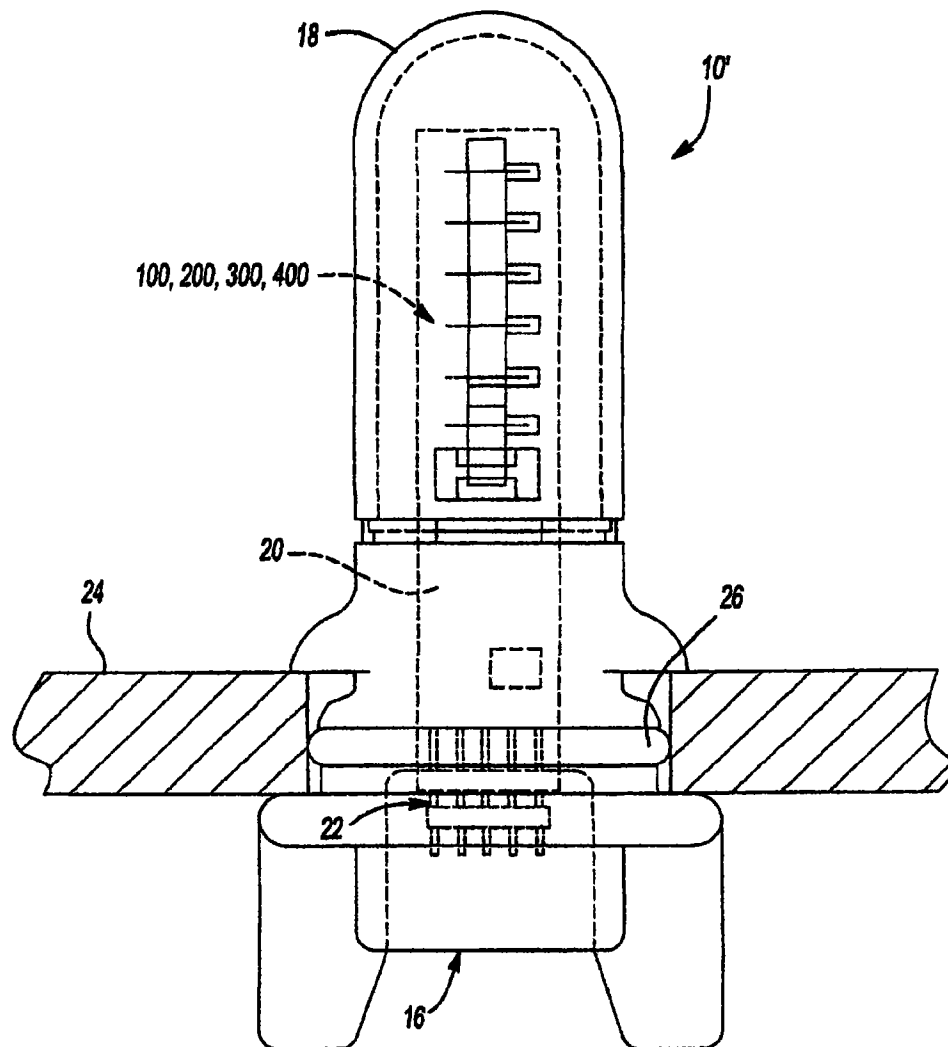


Fig-11

U.S. Patent

Aug. 17, 2010

Sheet 6 of 9

US 7,775,105 B2

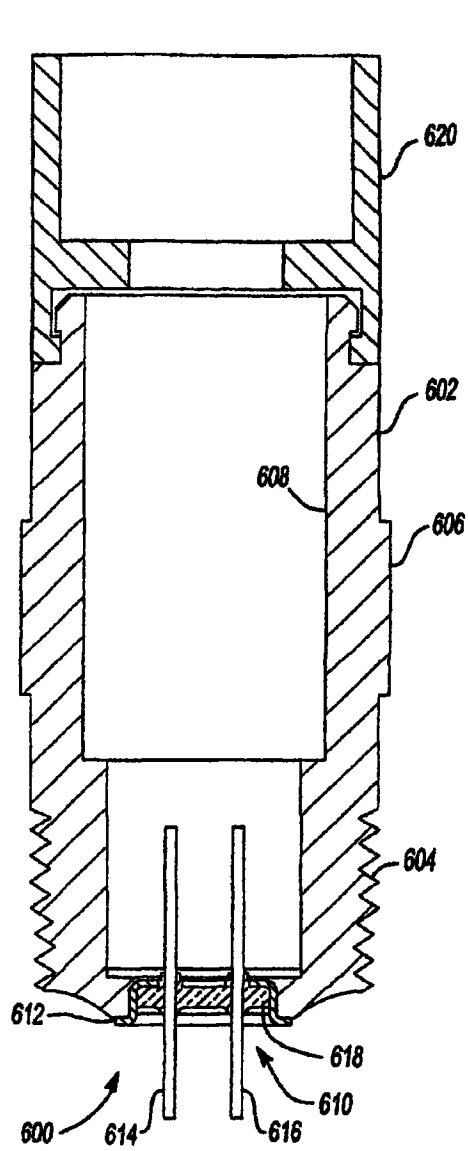


Fig-12

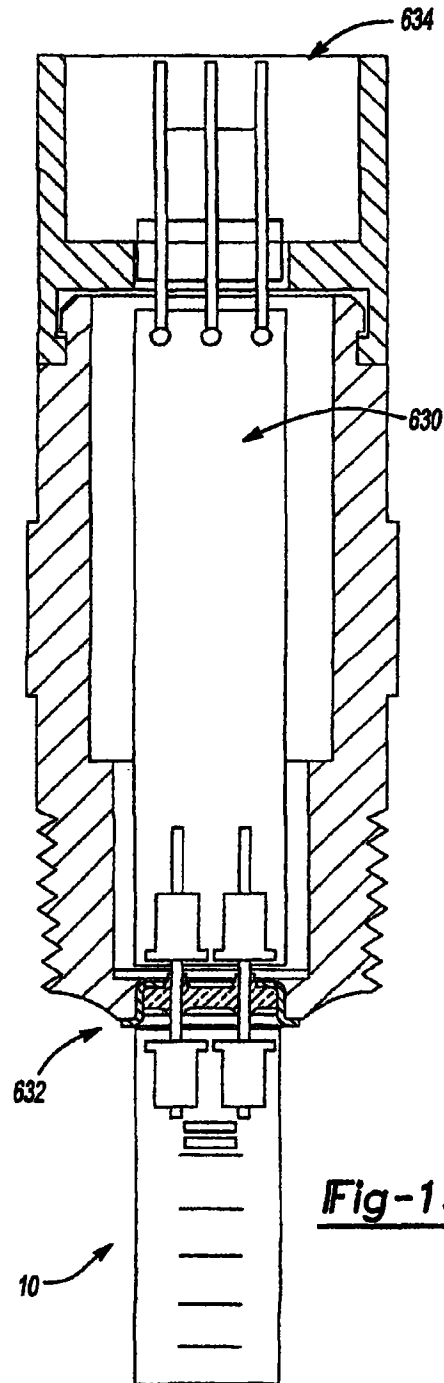


Fig-13

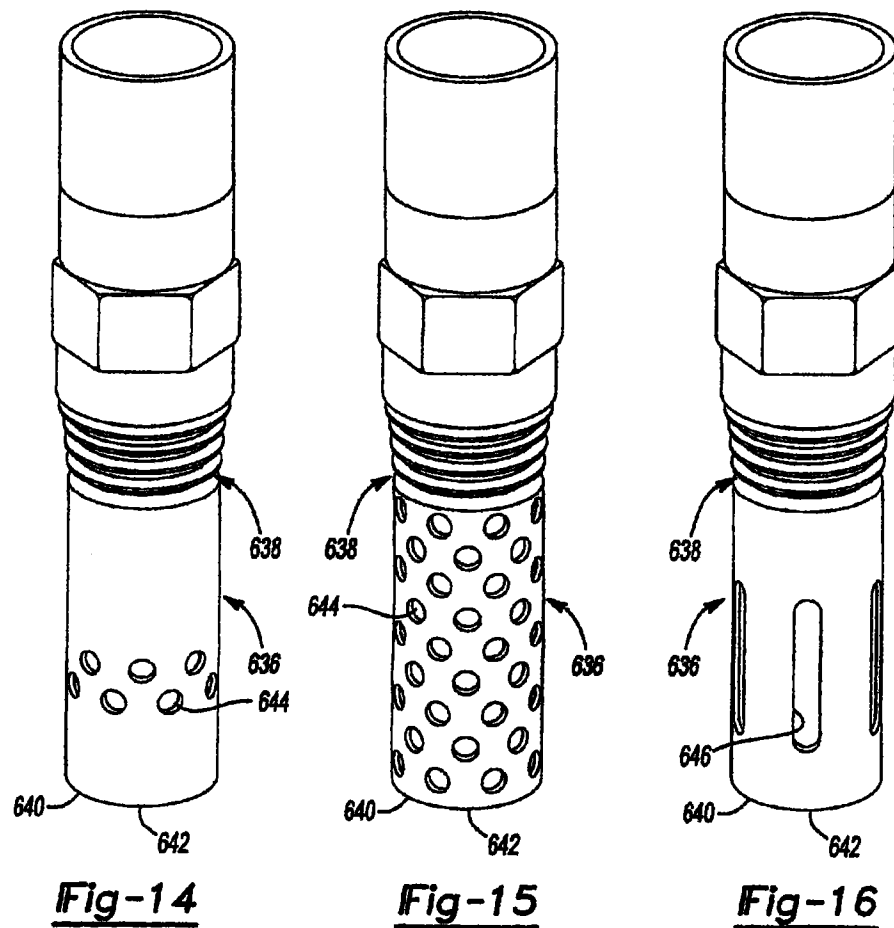
10

U.S. Patent

Aug. 17, 2010

Sheet 7 of 9

US 7,775,105 B2



U.S. Patent

Aug. 17, 2010

Sheet 8 of 9

US 7,775,105 B2

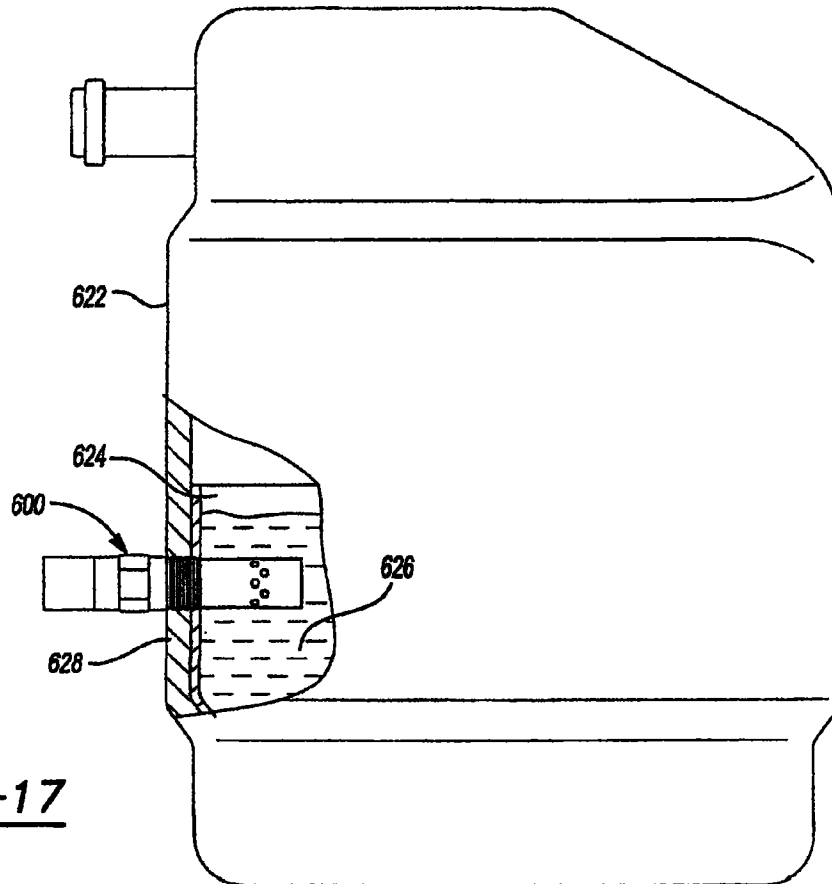


Fig-17

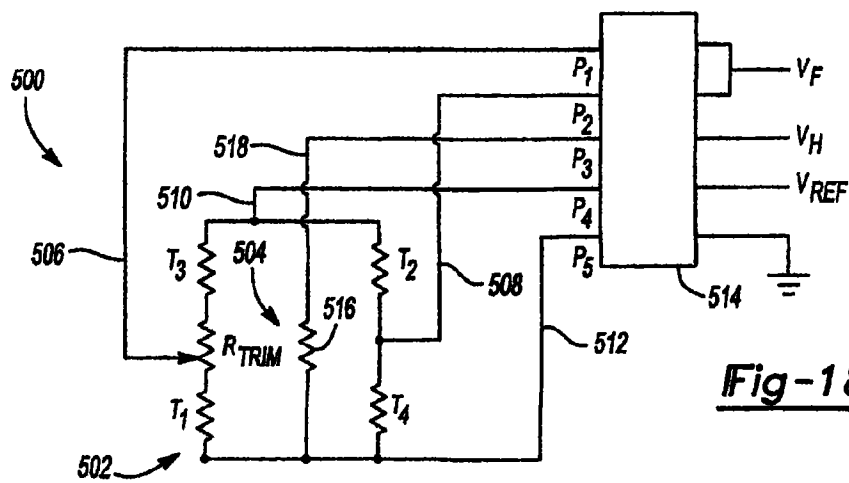


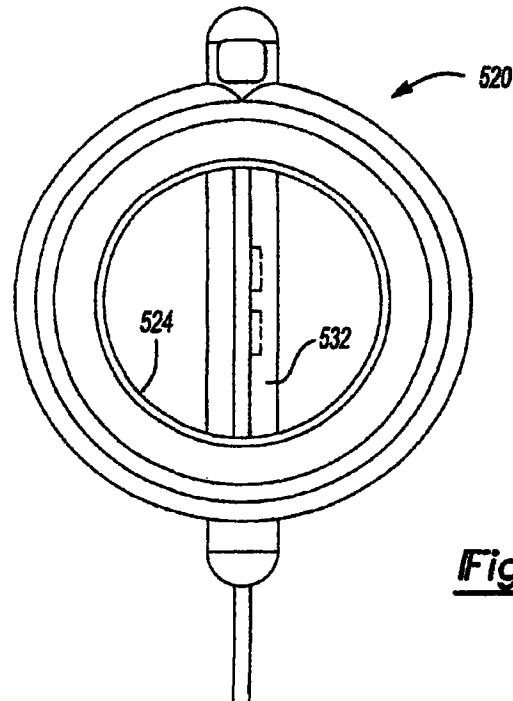
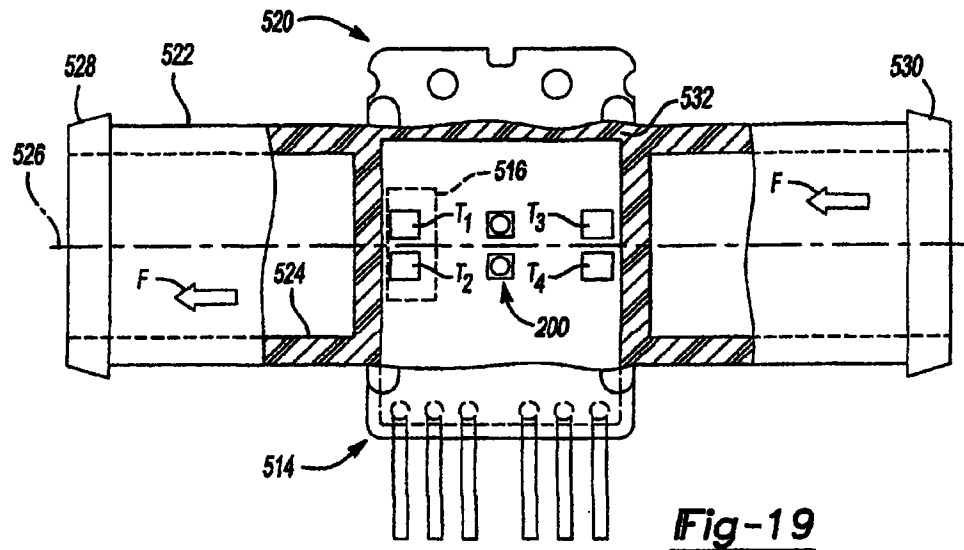
Fig-18

U.S. Patent

Aug. 17, 2010

Sheet 9 of 9

US 7,775,105 B2



US 7,775,105 B2

1

MULTI-FUNCTION SENSOR**CROSS-REFERENCE TO RELATED APPLICATIONS**

This application claims the benefit of U.S. Provisional Application No. 60/564,129, filed on Apr. 21, 2004. The disclosure of the above application is incorporated herein by reference.

FIELD OF THE INVENTION

The invention relates generally to devices used to measure certain ambient conditions within an environment, such as the level or flow rate of a fluid or within a vessel or container, the turbidity of the fluid, and the temperature or pressure of the fluid and/or the ambient environment.

BACKGROUND OF THE INVENTION

There exists a wide variety of applications in which it is desirable to measure and/or monitor to some degree certain ambient conditions within a container or the like, such as the level of a fluid, the flow rate of a fluid, the turbidity of a fluid, the temperature of a fluid or its surrounding environment and the ambient pressure. Such applications may range from monitoring these conditions in various systems, such as an internal combustion engine or fuel tank, a pump or compressor, or even within a tank or tub, such as for a household appliance like a dishwasher or clothes washer.

In each of these applications it is desirable that the multi-function sensor be capable of providing a reliable, accurate indication of the fluid level, fluid flow rate, turbidity, temperature and/or pressure over an extended period of time without requiring periodic maintenance. In many applications the sensor must be capable of enduring various degrees of vibration, heat or other hostile environmental elements, as well as space limitations. Additionally, in some applications utilizing sealed vessels such as hermetic compressors and household appliances, it is desirable to minimize the number of penetrations through the wall(s) of the vessel in order to reduce the potential for leakage.

Various types of devices have been developed over the years for separately sensing individual conditions such as fluid level, fluid flow rate, fluid turbidity, fluid and/or ambient temperature, and fluid and/or ambient pressure. Such sensor devices, however, have not combined the multiple functionalities into a single sensor device.

SUMMARY OF THE INVENTION

The invention provides an extremely reliable multi-function sensor which is compact and simple in design and can be manufactured at very low costs. Further the sensor of the invention can be encapsulated or coated with a variety of suitable materials to enable it to maintain prolonged operation in numerous different and potentially hostile ambient environments.

The multi-function sensor of the invention incorporates a combination of more than one of a fluid level sensing component or a fluid flow rate sensing component, a turbidity sensing component, a temperature sensing component and a pressure sensing component.

The fluid level sensing component comprises a module having at least one first thermocouple junction(s) arranged along a substrate with a suitable heater arranged in close proximity. In order to compensate for ambient temperature, a

2

second, compensating thermocouple junction is associated with each of the at least one first thermocouple junction(s) and laterally spaced therefrom. The first and second thermocouple junctions are interconnected in series with respective first and second thermocouple junctions alternating in the serial interconnection. The first one(s) of the thermocouple junction(s) provide an indication of a rate of heat dissipation which is directly related to the level of the fluid in which the component is placed, while the second thermocouple junction(s) provide a compensation factor dependent upon the ambient temperature.

The fluid flow rate sensing component comprises a probe having a detection module adapted to change condition in response to the flow of the fluid, and a control module that is electrically connected to the probe that monitors the condition of the detection module over time (e.g., a temperature), determines a rate of change of that condition over time, and generates an output that is indicative of the rate of flow of the fluid.

The turbidity sensing component comprises a module for measuring the state of cleanliness (or conversely "dirtying") of a fluid. A turbidity measurement is often used to indirectly determine the state of cleanliness of a product to be cleaned, such as within a household appliance like a clothes washer or dishwasher. The turbidity sensing component utilizes a light beam propagating through a fluid medium to determine, for example, whether the fluid is clouded by particulate matter suspended in the fluid. The extent to which the light is transmitted, reflected or "scattered" through the medium, correlates and may be calibrated to measure the turbidity of the fluid.

Additionally, temperature and pressure sensing components of the multi-function sensor comprise respective modules having thermocouple junctions for providing signals indicative of these conditions in their ambient environments.

The arrangement of the multi-function sensor of the invention not only provides a very simple and reliable device for obtaining measurements for multiple ambient conditions in an environment, but also further minimizes the number of mounting locations on a container and the corresponding penetrations extending through the container wall. This feature is significant, particularly when the sensor is to be employed within a closed or sealed system.

A hermetic interface is further provided for use together with the multi-function sensor. The hermetic interface enables the sensor to be employed in apparatus having a sealed or closed container into which the multi-function sensor extends through a container wall, such as in a hermetically-sealed compressor or an appliance like a clothes washer or dishwasher. The hermetic interface can include a hermetic or semi-hermetic feedthrough that provides one or more pin connectors or leads for electrically connecting to the sensor. The hermetic interface enables power from outside of the container to be provided to the multi-function sensor inside of the container and output from the sensor inside the container to pass from to the outside of the container, while not compromising the container's seal. The hermetic interface can further include circuitry to regulate the power carried to the multi-function sensor, as well as circuitry for conditioning the sensor's output signal(s).

Also, a protective shield can be provided to surround the sensor. The shield serves as a barrier between the sensor and sloshing fluid disposed within the container.

Additional advantages and features of the invention will become apparent from the subsequent description and the appended claims taken in conjunction with the accompanying drawings.

US 7,775,105 B2

3

BRIEF DESCRIPTION OF THE DRAWINGS

FIG. 1 is schematic block diagram of a multi-function sensor in accordance with the invention;

FIG. 2 is a schematic circuit diagram of an exemplary liquid level sensor module of the multi-function sensor of the invention;

FIG. 3 is a schematic circuit diagram of an exemplary reflective-mode turbidity sensor module of the multi-function sensor of the invention;

FIG. 4 is a graph illustrating the output of the reflective-mode turbidity sensor module of FIG. 3 for three exemplary turbidity levels;

FIG. 5 is a schematic circuit diagram of an exemplary transmissive-mode turbidity sensor module of the multi-function sensor of the invention;

FIG. 6 is a graph illustrating the output of the transmissive-mode turbidity sensor module of FIG. 5 for three exemplary turbidity levels;

FIG. 7 is a schematic circuit diagram of an exemplary pressure sensor module of the multi-function sensor of the invention;

FIG. 8 is a schematic circuit diagram of an exemplary temperature sensor module of the multi-function sensor of the invention;

FIG. 9 is an exploded perspective view of one embodiment of the multi-function sensor of the invention;

FIG. 10 is an exploded perspective view of another embodiment of the multi-function sensor of the invention;

FIG. 11 is a cross-sectional front view of a multi-function sensor of the invention, such as that shown in FIG. 9 or 10, which is installed through the wall of an appliance;

FIG. 12 is a cross-sectional front view of a hermetic interface that may be used with the multi-function sensor of the invention;

FIG. 13 is a cross-sectional front view of the hermetic interface of FIG. 12 and including a multi-function sensor of the invention disposed therein;

FIG. 14 is a front view of the hermetic interface of FIG. 12 having a first protective shield disposed thereon;

FIG. 15 is a front view of the hermetic interface of FIG. 12 having a second protective shield disposed thereon;

FIG. 16 is a front view of the hermetic interface of FIG. 12 having a third protective shield disposed thereon;

FIG. 17 is a view of a sealed vessel, such as a hermetic compressor, having a multi-function sensor in accordance with the invention installed therein;

FIG. 18 is a schematic circuit diagram of an exemplary fluid flow rate sensor module of the multi-function sensor of the invention;

FIG. 19 is a front view, in partial cross-section, of another embodiment of the multi-function sensor of the invention; and

FIG. 20 is an end view of the embodiment of the multi-function sensor of FIG. 19.

DESCRIPTION OF THE PREFERRED EMBODIMENTS

Referring now to the drawings and in particular to FIG. 1, there is shown a schematic block diagram of a multi-function sensor 10 in accordance with the invention. Multi-function sensor 10 comprises a printed circuit board 12 upon which a plurality of sensor modules 100 or 200, 300, 400, and 500 are supported. The sensor modules 100 or 200, 300, 400, and 500 may include a liquid level sensor module 100, a turbidity sensor module 200, a pressure sensor module 300 and a

4

temperature sensor module 400. Alternatively to the liquid level sensor 100, a fluid flow rate sensor module 500 may be incorporated into the multi-function sensor 10. Although FIG. 1 schematically depicts the several sensor modules 100, 200, 300, 400, 500 in a particular combination, it is understood that any combination of the several sensor modules 100, 200, 300, 400, 500 may be employed to provide a multi-function sensor in accordance with the invention.

The printed circuit board 12 includes a relatively rigid, elongate substrate 14. The substrate 14 may be fabricated from a variety of different materials but will preferably be made from a suitable printed circuit board material having good electrical insulating capabilities and preferably resistant to degradation from the environment in which it will be utilized. It is also preferable that the material be relatively thin to promote heat transfer from one surface to the other so as to promote faster response time in the sensor modules 100, 200, 300, 400, 500.

Preferably, the printed circuit board 12 and sensor modules 100, 200, 300, 400, 500 are coated or encapsulated with a thin, electrically insulating coating. The coating affords protection to the sensor from environmental elements and reduces the possibility of a short circuit. Such coatings must have good heat transfer characteristics but yet must also provide sufficient electrical insulation to the components. Also, the coating must be translucent at the operating wavelength of the light source that is associated with the turbidity sensor module, as described below. Additionally, it is highly desirable that the coating be able to clearly shed the liquid in the environment which the multi-function sensor 10 is to be used so as to minimize the potential for erroneous readings. One such material that is contemplated for this invention is commercially available under the tradename Parylene. One of Dow Corning Corporation's RTV elastomeric conformal coatings may provide another source of suitable coating materials.

The multi-function sensor 10 of the invention can incorporate a liquid level sensor module 100 for sensing the level of a fluid in an environment. The liquid level sensor module 100 is supported on the printed circuit board 12. A suitable liquid level sensor module that may be integrated into the multi-function sensor 10 is shown and described in U.S. Pat. No. 6,546,796, entitled "Liquid Level Sensor," issued Apr. 15, 2003 and owned by Therm-O-Disc, Incorporated, the assignee of the present patent application, the disclosure of which is hereby incorporated by reference.

In particular, at col. 2, line 38 through col. 9, line 30, U.S. Pat. No. 6,546,796 describes a liquid level sensor utilizing a plurality of thermocouple junctions grouped in pairs and connected in series, with the pairs being spaced along a line generally extending in the direction along which the liquid level may vary. A first or "hot" thermocouple junction of each pair of thermocouple junctions is located in relatively close thermal proximity to an electrically powered heater. The second or "cold" thermocouple junction of each pair of thermocouple junctions is relatively laterally offset from the first thermocouple junction and the heater along a line extending parallel to the surface of the liquid to be measured. Any number of pairs of first and second thermocouple junctions may be selected so as to ensure a sufficient number and spacing to cover a desired range of liquid level to be sensed, as well as the degree of resolution desired. An output voltage V_{LL} measured across the thermocouple junctions is indicative of the level of the liquid being sensed.

FIG. 2 illustrates a schematic circuit diagram for an exemplary liquid level sensor module 100 for the multi-function sensor 10 of the invention. As shown, the liquid level sensor

US 7,775,105 B2

5

module 100 generally comprises a heater circuit 102 and a thermocouple circuit 104. The heater circuit 102 includes a plurality of discrete heaters 106, such as resistors. The thermocouple circuit 104 comprises a plurality of "hot" 108 and "cold" 110 thermocouple junctions which are connected in series, alternating between hot 108 and cold 110 thermocouple junctions. A voltage divider 112 and an amplifier 114 also form part of the thermocouple circuit 104 in the embodiment shown in FIG. 2.

A plurality of traces 116, 118, 120 lead to a multi-pin connector 122 comprising a plurality of pins, P_1, P_2, P_3 . Trace 118 terminates at pin P_2 , where a reference voltage V_{REF} is applied to both the heater circuit 102 and the voltage divider circuit 112. Trace 116 is coupled to the output of the amplifier 114 in the thermocouple circuit 104 and terminates at pin P_1 where an output voltage V_{LL} can be read. The output voltage V_{LL} is indicative of the liquid level that is sensed by the liquid level sensor module 100. Trace 120 terminates at pin P_3 which is connected to ground.

In operation, the reference voltage V_{REF} applied to the heater circuit 102 raises the temperature of the heaters 106 above the ambient temperature. Thermal energy from the heaters 106 is conducted to the hot thermocouple junctions 108, which are in relatively close proximity to the heaters 106. Each hot thermocouple junction 108 generates a voltage potential when heated, the magnitude of which increases with increases in its temperature. The hot thermocouple junctions 108 are connected in series and the voltage potential generated by each hot thermocouple junction 108 is additive to the others. The total voltage potential generated when the liquid level sensor module 100 is not immersed in liquid, V_{NT} , equals n times the potential generated by a single hot thermocouple junction, where n is the number thermocouple junctions.

However, when a hot thermocouple junction 108 is immersed in a liquid, the liquid's greater thermal transfer efficiency (as opposed to gaseous fluids) reduces the amount that the hot thermocouple junction 108 is heated by the heater 106. Hence, it generates a lower voltage potential than it would were it not immersed in the liquid. Correspondingly, the total voltage potential for all of the thermocouple junctions is reduced. When the total voltage potential, then, falls below V_{NT} , it is indicative of the sensor's presence in a liquid environment. As more of the thermocouple junctions become immersed in the liquid, the total voltage potential continues to decrease until it reaches a value V_{FT} , which is the point at which all of the thermocouples are fully immersed in the liquid.

Ambient temperature, however, influences the amount of heat that is conducted to the hot thermocouple junctions. Hence, the voltage potential generated by the hot thermocouple junctions 108 is also affected by ambient temperature. To account for ambient temperature variations, the thermocouple circuit 104 includes corresponding cold thermocouple junctions 110 for each of the hot thermocouple junctions 108. The cold thermocouple junctions 110 are not located in proximity to the heaters 106 and, therefore, thermal energy from the heaters 106 is not conducted to the cold thermocouple junctions 110. The cold thermocouple junctions 110 remain at ambient temperature.

To account for variations in ambient temperature, then, each cold thermocouple junction 110 is wired in the thermocouple circuit so as to generate a voltage potential that is of opposite polarity to that of its associated hot thermocouple junction 108. Because the cold thermocouple junctions 110 are interconnected in an alternating series relationship with the hot thermocouple junctions 108, their opposite polarity voltage potentials subtract from the voltage potentials that are

6

generated by the hot thermocouple junctions 108. As one having ordinary skill in the art will appreciate, the summation of the hot and cold thermocouple junctions' 108, 110 voltage potentials result in the output voltage, V_{LL} , which is not only indicative of the liquid level sensed by sensor module 14, but also eliminates the ambient temperature's influence on the output.

The liquid level sensor module 100 example shown schematically in FIG. 2 provides sensing capabilities for four discrete liquid levels (i.e., it has four pairs of hot and cold thermocouple junctions 108, 110). Alternatively, the multi-function sensor of the invention may incorporate a liquid level sensor module that simply senses whether a threshold fluid level has been attained. One such liquid level sensor is shown and described in U.S. Pat. No. 6,862,932 entitled "Liquid Level Sensor," issued Mar. 8, 2005 and owned by Therm-O-Disc, Incorporated, the assignee of the present patent application, the disclosure of which is hereby incorporated by reference. In particular, at col. 10, line 55 through col. 14, line 2, U.S. Pat. No. 6,862,932 describes a liquid level sensor operating on the same principles as the liquid level sensor described above, but utilizing only a single pair of thermocouple junctions, one "hot" and one "cold." An output voltage of a first value is associated with the immersion of the sensor in the liquid and indicates that the level of the liquid has reached or exceeded a threshold level. An output voltage of a second, higher value indicates that the liquid has fallen below the threshold level.

Referring now to FIGS. 3-6, a turbidity sensor module 200 for use in the multi-function sensor 10 of the invention is schematically shown and described. The turbidity sensor module 200 senses the state of cleanliness (or conversely "dirtying") of a fluid. Generally speaking, the turbidity sensor module 200 utilizes a light beam propagating through a fluid to determine, for example, whether the fluid is clouded by particulate matter that is suspended in the fluid. The extent to which the light is transmitted, reflected or scattered through the fluid, correlates to and may be calibrated to measure the relative turbidity of the fluid.

FIG. 3 shows a schematic circuit diagram of a first embodiment of an exemplary turbidity sensor module 200'. The turbidity sensor module 200' comprises a reflective mode-type optical sensor. The turbidity sensor module 200' incorporates a light source 202', such as a light emitting diode (LED), that propagates a light signal, such as an infra-red light signal for example. A photosensor 204', such as a photodiode or phototransistor, is paired with the light source 202' and is arranged electrically in parallel to the light source 202'. The photosensor 204' is included in the turbidity sensor module 200' to detect the intensity of the light that is reflected by the fluid in which it is disposed.

Generally speaking, the photosensor 204' acts as a variable resistor, decreasing in resistance as the amount of reflected light being detected increases. The greater the turbidity the fluid, the greater amount of light that is reflected by the fluid and detected by the photosensor 204'. Thus, the higher the turbidity, the lower the resistance of the photosensor 204'.

The light source 202' and photosensor 204' components that may be employed in the turbidity sensor module 200' of the invention are well-known and commercially available. Components which are suitable for incorporation into the turbidity sensor module 200' include a surface mount LED which is available from Fairchild Semiconductor under part no. QEB421 and a surface mount silicon phototransistor also available from Fairchild Semiconductor under part no. QSB320. The LED and photosensor components are gener-

US 7,775,105 B2

7

ally mounted on a substrate in a relationship that is preferably either at a right angle (i.e., at 90°) or side-by-side (i.e., at 180°).

Referring again to FIG. 3, the turbidity sensor module 200' includes a plurality of traces 206', 208', 210' that lead to a multi-pin connector 212' comprising a plurality of pins, P₁, P₂, P₃. Trace 206' terminates at pin P₁, where a reference voltage V_{REF} is applied to the light source 202' and one side of the photosensor 204'. Trace 208' is coupled to the other side of the photosensor and terminates at pin P₂ where an output voltage V_{TUR} can be read. The output voltage V_{TUR} is indicative of the turbidity of the fluid as sensed by the turbidity sensor module 200'. Trace 210' terminates at pin P₃ which is connected to ground.

The turbidity sensor module 200' operates as follows. The reference voltage V_{REF} is applied to the circuit and powers the light source 202'. Light emitted by the light source 202' propagates through the fluid. Any particulate matter that may be suspended in the fluid reflects at least some of the light back in the direction of the photosensor 204', where it is detected. The reflected light that is detected by the photosensor 204' causes an output voltage taken across the photosensor, V_{TUR}, to increase from a baseline value, which is less than V_{REF}. Once calibrated, the output voltage V_{TUR} is correlated to the turbidity measurement of the fluid.

FIG. 4 shows a graph illustrating the output in volts (V) versus turbidity (measured as nephelometric turbidity units (NTUs)) of a reflective-mode turbidity sensor module 200' constructed in accordance with the invention as shown in FIG. 3. Samples of fluid having known turbidity levels of 0 NTU, 20 NTU and 200 NTU were obtained. The sensor module 200' was subjected to each of the fluid samples. The reference voltage V_{REF} applied to the turbidity sensor module 200' was 5 volts. Corresponding output voltages V_{TUR} were measured for each of the fluid samples. Averages of several trials are shown at points A, B and C.

Turning to FIG. 5, a schematic circuit diagram of another embodiment of an exemplary turbidity sensor module 200" for use with the invention is shown. The turbidity sensor module 200" comprises a transmissive mode-type optical sensor which operates to detect the intensity of the light that is transmitted through the fluid in which it is disposed. The lower the turbidity of the fluid, the greater amount of light that is transmitted and detected by the photosensor. As turbidity of the fluid increases, so does the resistance of the photosensor.

The transmissive mode-type optical sensor of the turbidity sensor module 200" comprises a light source 202" and photosensor 204" that are paired together and packaged as a single component. The light source and photosensor are arranged in the package opposite to one another (i.e., at 0°). Transmissive mode-type optical sensors that are suitable for use in the turbidity sensor module 200" include optical switches which are commercially available from Fairchild Semiconductor under part no. CNY36 or from Optek Technology, Inc. under part no. OPB621.

As shown in FIG. 5, the turbidity sensor module 200" includes a plurality of traces 206", 208", 210" that lead to a multi-pin connector 212" comprising a plurality of pins, P₁, P₂, P₃. Trace 206" terminates at pin P₁, where a reference voltage V_{REF} is applied to the light source 202" and one side of the photosensor 204". Trace 210" is coupled to the other side of the photosensor 204" and terminates at pin P₃ where an output voltage V_{TUR} can be read. The output voltage V_{TUR} is indicative of the turbidity of the fluid as sensed by the turbidity sensor module 200". Trace 208" terminates at pin P₂ which is connected to ground.

8

When the reference voltage V_{REF} is applied to the circuit, the light source 202" emits light which propagates through the fluid and in the direction of the photosensor 204". Particulate matter that may be suspended in the fluid causes some of the light to be reflected or scattered, preventing it from reaching the photosensor 204". The light that is transmitted through the fluid is detected by the photosensor 204". When the turbidity of the fluid is low, light from the light source 202" is not impeded from reaching the photosensor 204". The photosensor 204", therefore, provides low resistance with little drop in voltage. The output voltage V_{TUR} approaches V_{REF}. As the turbidity of the fluid increases, more and more light is reflected or scattered and does not reach the photosensor 204". In such cases, the photosensor's 204" resistance also increases and the output voltage V_{TUR} is reduced.

FIG. 6 is a graph illustrating the output in volts (V) versus turbidity (NTUs) of the transmissive-mode turbidity sensor module 200" constructed in accordance with the invention as shown in FIG. 5. The same three samples of fluid of known turbidity levels 0 NTU, 20 NTU and 200 NTU were used and the results obtained. The reference voltage V_{REF} applied to the turbidity sensor module 200" again was 5 volts. Corresponding output voltages V_{TUR} were measured for each of the fluid samples. Averages of several trials are shown at points D, E and F.

In certain applications for the multi-function sensor 10, it may be necessary to sense the pressure in the ambient environment. Alternatively, the multi-function sensor 10 may be employed in an environment where it is subjected to such wide variations in pressure that the accuracy of its outputs relative to other sensed conditions such as liquid level, for example, are impaired. Thus it may be desirable to provide an output from the multi-function sensor 10 indicative of the ambient pressure within the environment.

A pressure sensor module 300 suitable for use with the multi-function sensor 10 of the invention can incorporate a pair of hot and cold thermocouples, as shown and described in U.S. Pat. No. 6,546,796 at col. 6, line 3 through col. 7, line 10, which is hereby incorporated by reference. FIG. 7 shows a schematic circuit diagram of an exemplary pressure sensor module 300. The pressure sensor module 300 generally comprises a heater circuit 302 and thermocouple circuit 304. The heater circuit 302 includes a discrete heater 306, such as a resistor. The thermocouple circuit comprises a "hot" 308 and a "cold" 310 thermocouple junction, which are connected in series, a voltage divider 312 and an amplifier 314.

A plurality of traces 316, 318, 320 of the pressure sensor module 300 lead to a multi-pin connector 322 comprising a plurality of pins, P₁, P₂, P₃. Trace 318 terminates at pin P₂, where a reference voltage V_{REF} is applied to both the heater circuit and the voltage divider circuit. Trace 316 is coupled to the output of the amplifier 314 in the thermocouple circuit 304 and terminates at pin P₁ where an output voltage V_P can be read. The output voltage V_P is indicative of the pressure that is sensed by the pressure sensor module 300. Trace 320 terminates at pin P₃ which is connected to ground.

In operation, when the reference voltage V_{REF} is applied to the heater circuit 302 the temperature of the heater 306 is raised above the ambient temperature. Thermal energy from the heater 306 is conducted to the hot thermocouple junction 308, which is located in relatively close thermal proximity to the heater 306. The cold thermocouple junction 310 is relatively laterally offset from the hot thermocouple junction 308 and the heater 306. An output voltage V_P measured at P₁ is indicative of the pressure being sensed and is compensated for temperature. More specifically, the heater 306 transfers heat to the hot thermocouple junction 308, which generates a

US 7,775,105 B2

9

potential indicative of its temperature. The heating of the hot thermocouple junction 308 by the heater 306, however, is offset by heat radiated or otherwise transferred to the surrounding environment. The rate at which heat is transferred to the surroundings is dependent upon ambient pressure. That is, a greater amount of heat will be transferred to the surroundings when the surroundings are at higher pressure. Thus, the potential generated by the hot thermocouple junction 308 decreases as pressure increases. The pressure sensor module 300 of the multi-function sensor 10 of the invention provides an output voltage V_p that is indicative of the ambient pressure within the environment.

The output voltage V_p may be used for a variety of purposes, including providing an overpressure alarm or to generate a correction factor for other outputs of the multi-function sensor 10. If desired for a particular application, the output from pressure sensor module 300 may be supplied to suitable signal conditioning circuitry such as that described herein. Such signal conditioning circuitry may be incorporated onto circuit board 12 or may be located at a remote location.

FIG. 8 shows a schematic circuit diagram of an exemplary temperature sensor module 400 for use in the multi-function sensor 10. The temperature sensor module 400 may comprise a low profile, surface mount chip thermistor 402 or some other type of temperature dependent, variable resistor. An exemplary surface mount chip thermistor that is suitable for use in the multi-function sensor 10 is commercially available from Panasonic under part no. ERT-J1VV104J. As shown in FIG. 8, an output voltage V_T is measured across the thermistor when a reference voltage V_{REF} is applied to the circuit. The output voltage V_T can be calibrated to correspond to read the ambient temperature.

In order to ensure accurate and consistent readings from the multi-function sensor 10, it is important that the voltage applied to the sensor modules 100, 200, 300, 400, 500 be closely regulated (preferably $\pm 1\%$). As is known in the art, this may be accomplished by providing suitable power supply regulating circuitry on the circuit board 12. Alternatively a remote regulated source of power which supplies power to the multifunction sensor may be provided.

While the voltage outputs from the multi-function sensor 10 both have a high degree of resolution and have an excellent signal-to-noise ratio, one or more of the voltage outputs may benefit from additional manipulation for a particular application. It is therefore contemplated that conditioning one or more of the outputs from the multi-function sensor 10 may be desirable. A signal conditioning circuit can comprise amplifiers, filters, or similar components. A suitable signal conditioning circuit is shown and described in FIG. 4 of U.S. Pat. No. 6,546,796 and the discussion related thereto at col. 5, line 31 to col. 6, line 2, which is hereby incorporated by reference. It should be appreciated that this or another suitable signal conditioning circuit can be used with the multi-function sensor 10 of the invention.

Either or both the power supply regulating circuitry and the signal conditioning circuitry, as desired, may be integrated onto the printed circuit board 12 of the multi-function sensor 10. Alternatively, such circuitry can be disposed on the substrate of a separate printed circuit board component, like a lead-frame, that is coupled to both the multi-function sensor 10 and other hardware associated with the sensor, like control electronics or a power supply, for example. The lead-frame can then be disposed at a location remote from the sensed environment, leaving only the sensor modules within the environment where conditions are to be sensed.

10

FIGS. 9 and 10 show exploded perspective views of two exemplary embodiments of the multi-function sensor 10 of the invention.

As shown in the figures, the exemplary multi-function sensors 10', 10'' are each attached to a base 16 and may include a protective shield 18. A lead-frame 20 comprising a multi-pin connector 22 serves to provide a connection between the multi-function sensor 10', 10'' and control electronics (not shown) of the device employing the sensor. In addition, as already discussed, the lead-frame may include power regulating and/or signal conditioning circuitry for the multi-function sensor. FIG. 11 shows a cross-sectional front view of a multi-function sensor 10' of the invention, such as that shown in FIG. 9, which is installed through the wall 24 of an appliance. The multi-function sensor 10' may be housed in, for example, a dishwasher tub. An O-ring 26 located on the base 16 provides a seal to prevent fluid from leaking at the installation location of the sensor 10'.

The inclusion and arrangement of any combination of the sensor modules 100, 200, 300, 400 depend on the application for the sensor. For example, if the level, turbidity and temperature of the wash water in a dishwasher is to be monitored, then those sensor modules would be disposed such that they are submersed in the water during normal operation.

Turning now to FIGS. 12-17, a hermetic interface 300 for use in combination with the multi-function sensor 10 of the invention is shown. As depicted in FIG. 17, the hermetic interface provides the multi-function sensor 10 with the ability to transmit its outputs through the wall of a closed, highly pressurized vessel, while still maintaining the sealed nature of the vessel.

As shown in FIG. 12, the hermetic interface 600 includes a generally elongate cylindrical housing 602 having external screw threads 604 at one end and flats 606 to accommodate a wrench, for example. A bore 608 extends the length of the housing 602. At one end of the bore 608 is a hermetically sealed electrical feedthrough 610 comprising a metallic body 612 through which extend a plurality of current conducting pins 614, 616 that are hermetically sealed in the body 612 by a glass-to-metal seal 618. The feed through 610 is fit into the bore 608 and hermetically sealed to the housing 602, such as by welding, brazing, solder, epoxy, other mechanical fastening or any suitable means. An end cap 620 may also be attached to the hermetic interface 600 at its end opposite the screw threads 604.

The multi-function sensor 10 connects to pins 614, 616 by a suitable means such as welding, mechanical fastening or any suitable means of attachment including epoxy or solder, or a combination thereof. Although only two pins 614, 616 are illustrated, this is merely exemplary and any number of pins that are required may be included in the interface.

Once assembled with the hermetic interface 600, the multi-function sensor 10 may be used in a highly pressurized vessel 622 having a sealed compartment 624 (as shown in FIG. 17, for example) for determining the presence of a predetermined amount of fluid 626 while concurrently maintaining the sealed nature of the vessel 622. Although the hermetic interface 600 is shown to be attached to the vessel 622 by threaded engagement with a wall 628 of the vessel 622, it should be noted that any suitable means for attaching the hermetic interface 600 to the vessel 622 that concurrently maintains the sealed relationship of the hermetic interface 600 with the opening, such as welding or epoxy, may also be used.

As best illustrated in FIG. 13, the housing 602 of the hermetic interface 600 is adapted to receive within its bore 608 the lead-frame 630. The lead-frame 630 connects to the multi-function sensor 10 at a multi-pin connector 632.

US 7,775,105 B2

11

Although only two pin connections are shown, the particular number of pin connections can vary as necessary. At the opposite end, the lead-frame 630 connects to a connector plug 634. By way of the lead-frame 630, the outputs from the multi-function sensor 10 can ultimately be supplied to suitable remotely located processing and/or display devices for monitoring and/or recording the various conditions being sensed by the multi-function sensor 10, for example.

As shown in FIGS. 14-17, a protective shield 636 may be provided to prevent damage to the sensor 10. The shield 636 also serves to dampen the changes in liquid level which may occur as a result of movement of the vessel within which the liquid is contained and/or agitation of the liquid resulting from movement of apparatus within the liquid containing vessels which could cause inaccurate readings by the sensor 10.

The shield 636 is a generally cylindrical member having a proximate end 638 fixedly attached to the housing 602 and a distal end 640 extending away from the housing 602. The shield 636 further includes a central bore 642 extending along its length (and may be optionally open or closed at its distal end 640), whereby the bore 642 is operable to receive the sensor. The shield 636 includes a plurality of apertures, like holes 644 or slots 646, to allow the liquid 626 to flow into and out of the bore 642 at a predetermined rate for interaction with the sensor. The specific number of apertures as well as their size may be varied depending on the viscosity of the liquid whose level is to be sensed as well as the degree of anticipated agitation of the liquid and desired responsiveness of the sensor. That is to say, increasing the number and/or size of the apertures will enable the sensor to respond more rapidly to changes in liquid level but may result in a greater number of errors due to transient changes in the liquid level resulting from agitation of the liquid. Similarly, fewer and/or smaller holes will result in reduced sensitivity to agitation of the liquid but may increase the time required to sense a sudden drop in the liquid level.

The shield 636 may be fabricated from any material suitable for the environment within which it may be utilized including for example polymeric compositions or various metals. Alternatively, the shield 636 may be integrally formed with a portion of the vessel within which the liquid is contained or as part of other apparatus disposed within the vessel. It should also be noted that the shield may in some applications be in the form of a suitably shaped container sufficient to minimize or eliminate splashing of the liquid in the proximity of the sensor which could result in erroneous level readings or if splashing is not of concern, the shield or container may be eliminated in its entirety.

As shown in FIG. 17, the multi-function sensor 10 can be secured to the wall 628 in a position so as to be particularly immersed in the fluid 626 contained in the compartment 624. The multi-function sensor 10 then can operate to provide signal(s) indicative of ambient conditions within the vessel 622, such as temperature, fluid turbidity and whether the fluid is being maintained at a threshold level, for example. It should be noted that if desired, sensor 10 may be connected to suitable remotely located apparatus to sound an alarm, de-energize a device, or both, in response to an indication to any one of the conditions being sensed such as, for example, that the fluid level has dropped below a predetermined minimum, a desired temperature has been exceeded, etc.

Another sensor module that can be used in a multi-function sensor 10 of the invention is a fluid flow rate sensor module 500. One type of fluid flow rate sensor module 500 that is suitable to be integrated into a multi-function sensor 10 in accordance with the invention is a thermo-anemometer-type

12

fluid flow rate sensor. Such a device and method for its operation is shown and described in co-pending U.S. patent application entitled "Fluid Flow Rate Sensor and Method of Operation," Ser. No. 10/963,750, filed Oct. 13, 2004 and owned by Therm-O-Disc, Incorporated, the assignee of the present patent application, the disclosure of which is hereby incorporated by reference.

FIG. 18 shows a schematic circuit diagram of an exemplary fluid flow rate sensor module 500 that can be incorporated in the multi-function sensor 10 of the invention. The fluid flow rate sensor module 500 comprises a detection circuit 502 and a heating circuit 504.

The detection circuit 502 comprises a plurality of NTC thermistors T_1, T_2, T_3, T_4 that together form a 4-wire bridge circuit. The thermistor T_1 is coupled in series with thermistor T_3 to form one leg of the bridge and thermistor T_2 is coupled in series with thermistor T_4 to form the other leg of the bridge. Together, thermistor T_1 and thermistor T_3 are coupled in parallel with thermistor T_2 and thermistor T_4 . An optional trim resistor R_{trim} is included in series with thermistors T_1 and T_3 to enable the bridge circuit to be balanced, as is known in the art.

The detection circuit 502 also includes traces 506, 508, 510, 512 that lead to a multi-pin connector 514 having a plurality of pins P_1, P_2, P_3, P_4, P_5 . Trace 510 terminates at pin P_4 , where a reference voltage V_{REF} is applied to the circuit. Traces 506, 508 are respectively coupled to opposite legs of the circuit and terminate at pins P_1, P_2 . A differential output voltage V_F , which can be calibrated to represent a temperature difference (ΔT) across the bridge and between thermistors T_1, T_3 and thermistors T_2, T_4 as is well-known in the art, can be read at pins P_1, P_2 . Trace 512 terminates at pin P_5 which is connected to ground.

The heating circuit 504 of the fluid flow rate sensor module 500 comprises a heater 516. Trace 518 of the heating circuit 504 terminates at pin P_3 . A voltage V_H to power the heating circuit 504 is applied at pin P_3 . The heating circuit 504 is electrically insulated from the detection circuit 502, but not thermally insulated. The heater 516 is located proximate to thermistors T_1, T_2 such that thermal energy from the heater 516 is conducted to the thermistors T_1, T_2 . Thermal energy from the heater 516 is not, however, conducted to thermistors T_3, T_4 .

The fluid flow rate sensor module 500 can be incorporated with one or more of the other sensor modules 200, 300 and 400 into a probe 520, as shown in FIGS. 19 and 20. FIG. 19 is a front view, in partial cross-section, of such an embodiment of a multi-function sensor of the invention. FIG. 20 is an end view of the multi-function sensor of FIG. 19.

The probe 520 generally comprises a body 522. The body 522, as shown, is a generally a cylindrically-shaped tubular member having a passageway 524 extending through its entire length along a longitudinal axis 526. Fluid is able to flow through the passageway 524 of the body 522 in a direction along the longitudinal axis 526. Annular flanges 528, 530 may be located at opposite ends of the body 522 to facilitate connection of the probe 520 to a fluid source, such as the flexible supply hose of a water dispenser, for example.

Located intermediate the ends of the body 522 is a housing 532. The housing 532 extends through the body 522 in a direction generally perpendicular to the longitudinal axis 526. The housing 532 is disposed within the passageway 524. The shape of the housing 532 is designed to promote laminar flow of the fluid flow moving through the passageway 524 and across the surface of the housing 532. The sensor is received within the housing 532 such that the housing 532 encapsulates a portion of the sensor to protect it from physical contact

US 7,775,105 B2

13

with the fluid environment. The housing 532, however, is capable of conducting thermal energy from the fluid environment to the sensor.

Both the body 522 and the housing 532 are preferably manufactured from thermally conductive polymers, such as, for example, polypropylene, polyvinylchloride, polyacetylene, polyparaphenylene, polypyrrole, and polyaniline.

Ceramic and/or glass fillers mixed in with these base polymers have been shown to greatly enhance the material's thermal conductivity. One such material is known under the trade designation Konduit MT-210-14 and is available from GE/LNP.

The fluid flow rate sensor module 500 is generally received within the housing 532 such that it is perpendicular to the direction of fluid flow F through the passageway 524. Referring to FIGS. 19 and 20, the fluid flow rate sensor module's 500 is located within the housing 532 such that it lies within the passageway 524 of the body 522. The pin connectors P₁, P₂, P₃, P₄, P₅, however, extend outward from the housing 532. The detection circuit 502 and heating circuit 504 are arranged such that the thermistors T₁, T₂, T₃, T₄ and the heater 516 all lie within the passageway 524 of the body 522. Further, the arrangement of thermistors T₁, T₂, T₃, T₄ is such that the unheated thermistors T₃, T₄ lie upstream in the fluid from the heated thermistors T₁, T₂.

The use of four thermistors T₁, T₂, T₃, T₄ in the detection circuit 502 and the thermistors' T₁, T₂, T₃, T₄ physical arrangement in the passageway 524 of the body 522 provide further advantages. One significant advantage is that the differential output voltage V_F is automatically compensated for ambient temperature changes, i.e., changes in the temperature of the fluid. This is important because if significant and/or rapid changes in the fluid temperature occur, they could distort the output of the sensor 10 causing the sensor 10 to give inaccurate results.

The differential output voltage V_F of the fluid flow rate sensor module 500, however, represents a temperature difference (ΔT) across the bridge and not an absolute temperature (T). This is because the unheated thermistors T₃, T₄ on opposite sides of the bridge of the circuit counter-act the impact on the differential output voltage V_F caused by temperature changes in the fluid. Consequently, the compensated sensor module measures the change in relative temperature. From that temperature change, the fluid flow rate may be determined as taught in U.S. patent application entitled "Fluid Flow Rate Sensor and Method of Operation," Ser. No. 10/963,750, filed Oct. 13, 2004, which is hereby incorporated by reference.

Further improvements to optimize the thermal mass of the detection circuit 502 comprise utilizing a highly thermally conductive ceramic substrate upon which are screen printed a ceramic-filled carbon paste material that forms the thermistors T₁ through T₄. Such material is available from Heraeus Incorporated, Circuit Materials Division under the R100 Series designation. Such a configuration completely eliminates the discrete thermistor components in the detection circuit 502 and helps to reduce the thermal mass of the detection circuit 502.

Also, to improve the heat transfer characteristics and durability of the probe, it is contemplated that the housing 532 can be eliminated and a thin layer of a thermally conductive dielectric polymer or a glass material be applied directly to the sensor as a glaze to encapsulate and protect it from moisture and/or abrasion.

As may be appreciated, the multi-function sensor of the invention provides a relatively simple and reliable means for measuring and monitoring several conditions in an environ-

14

ment. The multi-function sensor of the invention is designed to provide continuous monitoring. The sensor is well suited for economical manufacturing and requires only a very limited space to accommodate it. Further, the sensor may offer a wide degree of resolution of the fluid level being sensed and may even accommodate increased resolution over a specific portion of the level range being sensed.

While it will be appreciated that the preferred embodiments of the invention disclosed are well calculated to provide the advantages and features above stated, it will be appreciated that the invention is susceptible to modification, variation and change without departing from the proper scope or fair meaning of the subjoined claims.

What is claimed is:

1. A multi-function sensor comprising:

a fluid level sensor module;
a turbidity sensor module;
a temperature sensor module; and
a pressure sensor module;

wherein the temperature sensor module comprises a temperature dependent, variable resistor; and
the pressure sensor module comprises a first electric circuit comprising a first thermocouple junction and a second thermocouple junction, said second thermocouple junction located in a spaced relationship from said first thermocouple junction; and

a second electric circuit comprising a heat source for raising the temperature of said first thermocouple junction above an ambient temperature.

2. A multi-function sensor comprising:

a fluid level sensor module; and
a turbidity sensor module;

wherein the fluid level sensor module comprises:

a first electric circuit comprising a first thermocouple junction and a second thermocouple junction, said second thermocouple junction located in a spaced relationship from said first thermocouple junction; and

a second electric circuit comprising a heat source for raising the temperature of said first thermocouple junction above an ambient temperature.

3. The multi-function sensor of claim 2 wherein the turbidity sensor module comprises a reflective-mode-type optical sensor comprising:

a light source; and
a photosensor; and wherein
said photosensor measures an amount of reflected light from said light source.

4. The multi-function sensor of claim 2 wherein the turbidity sensor module comprises a transmissive-mode-type optical sensor comprising:

a light source; and
a photosensor paired with said light source; and wherein
said photosensor measures an amount of transmitted light from said light source.

5. A multi-function sensor comprising:

a fluid level sensor module; and
a turbidity sensor module;

wherein the fluid level sensor module comprises:

a first electric circuit comprising:
a plurality of first thermocouples provided in longitudinally spaced relationship; and

a plurality of second thermocouples provided in longitudinally spaced relationship, respective ones of said plurality of second thermocouples being positioned in laterally spaced relationship to respective ones of said plurality of first thermocouples,

US 7,775,105 B2

15

said first and second thermocouples being electrically connected in an alternating series relationship; and a second electric circuit comprising:

a heat source for raising the temperature of each of said plurality of first thermocouples above an ambient temperature.

6. A multi-function sensor comprising:

a fluid level sensor module;

a turbidity sensor module; and

an electrically insulating rigid substrate,

wherein said fluid level sensor module and said turbidity sensor module are located on said substrate, and further comprising an electrically insulating coating covering at least said fluid level sensor module.

7. The multi-function sensor of claim 6, wherein said electrically insulating coating comprises Parylene.

8. A multi-function sensor comprising:

a substrate having a longitudinal axis;

a plurality of first thermocouples provided on one side of said substrate in longitudinally spaced relationship;

a plurality of second thermocouples provided on said one side of said substrate in longitudinally spaced relationship to each other, respective ones of said plurality of second thermocouples being positioned in laterally spaced relationship to respective ones of said plurality of first thermocouples,

said first and second thermocouples being electrically connected in an alternating series relationship;

a heat source for increasing the temperature of each of said plurality of first thermocouples; and

a heat sink provided on said substrate in close proximity to said plurality of second thermocouples;

a light source located at one end of said substrate; and

a photosensor paired with said light source;

said sensor being adapted to generate at least one signal indicative of each of the level of a liquid within a vessel and the turbidity of said liquid within said vessel.

9. A multi-function sensor comprising:

a substrate having a first axis;

a first electric circuit comprising a first thermocouple junction and a second thermocouple junction disposed on said substrate, said second thermocouple junction located in a spaced relationship from said first thermocouple junction along said first axis;

a second electric circuit comprising a heat source disposed on said substrate for raising the temperature of said first thermocouple junction above an ambient temperature;

a light source located at one end of said substrate; and

a photosensor paired with said light source; and wherein said sensor is adapted to generate at least one signal indicative of each of the level of a liquid within a vessel and the turbidity of said liquid within said vessel.

10. A multi-function sensor comprising:

a fluid flow rate sensor module;

a turbidity sensor module;

a temperature sensor module; and

a pressure sensor module;

wherein the temperature sensor module comprises a thermocouple junction and the pressure sensor module comprises a thermocouple junction.

16

11. The multi-function sensor of claim 10, wherein at least the fluid flow rate sensor module is encapsulated by a thermally-conductive polymer.

12. A multi-function sensor comprising:

a fluid flow rate sensor module; and

a turbidity sensor module;

wherein the fluid flow rate sensor module comprises a detection circuit and a heating circuit, the detection circuit comprising a plurality of thermistors and a plurality of resistors, the detection circuit adapted to provide a differential voltage that varies in response to a change in temperature of the thermistors and the heating circuit comprising at least one resistor in thermal communication with at least one thermistor.

13. The multi-function sensor of claim 12 further comprising a ceramic substrate and wherein the detection circuit and the heating circuit are deposited on the ceramic substrate.

14. The multi-function sensor of claim 13 wherein the detection circuit comprises a ceramic-filled carbon paste that is screen printed onto the ceramic substrate to form the plurality of thermistors.

15. The multi-function sensor of claim 12 further comprising a body comprising a tubular member having a longitudinal axis and a passageway extending therethrough in the direction of the longitudinal axis.

16. The multi-function sensor of claim 15, wherein the body further comprises a housing disposed within the passageway, and wherein the fluid flow rate sensor module is received within the housing such that at least a portion of the fluid flow rate sensor module lies within the passageway.

17. The multi-function sensor of claim 16, wherein at least one thermistor of the detection circuit lies within the passageway.

18. The multi-function sensor of claim 15, wherein the body comprises a thermally-conductive polymer.

19. The multi-function sensor of claim 12 wherein the turbidity sensor module comprises a reflective-mode-type optical sensor comprising:

a light source; and

a photosensor; and wherein

said photosensor measures an amount of reflected light from said light source.

20. The multi-function sensor of claim 12 wherein the turbidity sensor module comprises a transmissive-mode-type optical sensor comprising:

a light source; and

a photosensor paired with said light source; and wherein said photosensor measures an amount of transmitted light from said light source.

21. The multi-function sensor of claim 12, further comprising an electrical insulating rigid substrate.

22. The multi-function sensor of claim 21, wherein said fluid flow rate sensor module and said turbidity sensor module are located on said substrate, and further comprising an electrically insulating coating covering at least said fluid flow rate sensor module.

* * * * *

EXHIBIT B

CONFIDENTIALITY AGREEMENT

This Confidentiality Agreement is made and entered into this 12 day of DECEMBER 1997 by and between MAX EM and Therm-O-Disc, Inc. (hereinafter referred to as "Therm-O-Disc").

Purpose of Agreement

1.) It is the intention of the parties to set forth the terms by which certain proprietary or confidential MAX EM LIQUID SENSOR information provided to Therm-O-Disc, shall be maintained and returned to MAX EM such that it will remain confidential and will not be disclosed to any parties or entities not party to this Agreement.

Disclosure of Confidential Information to Therm-O-Disc

2.) In consideration of the obligations of Therm-O-Disc as set forth below, MAX EM agrees to provide certain proprietary or confidential information to Therm-O-Disc. MAX EM agrees that any such information shall be designated as "Proprietary" or "Confidential".

Obligations of the Recipient

3.) In consideration of the obligations of MAX EM as set forth in the Agreement, Therm-O-Disc agrees:

(a) That all Proprietary or Confidential information provided to it by MAX EM shall be maintained in strict confidence and will not, without the prior written consent of MAX EM be disclosed to any third parties;

(b) That the Proprietary or Confidential information will be used solely for the purpose of EVALUATE THE MAX EM LIQUID SENSOR TECHNOLOGY FOR POTENTIAL LICENSING TO THERM-O-DISC

(c) That it will instruct all employees to whom it has discussed or revealed any Proprietary or Confidential information that the information is not to be disclosed to third parties outside of Therm-O-Disc.

8-22-97-85521

Reference TPP1501

T-O-D FORM 1848 (Page 1 of 3)

EXHIBIT D

93-000003

(d) That it will use the same degree of care in safeguarding the Proprietary or Confidential Information as it uses in safeguarding its own proprietary or confidential information.

(e) That it will return all Proprietary and Confidential documents to MAX EM including any notes, reports, summaries, and other records regarding the contents of the Proprietary and Confidential documents if requested to do so by MAX EM in writing. (If any Proprietary and Confidential information is commingled with proprietary and confidential information of Therm-O-Disc, Therm-O-Disc shall have the option of destroying the Proprietary and Confidential information, or redacting the Proprietary and Confidential information of MAX EM from these documents and shall confirm in writing to MAX EM that it has done so.)

Definitions

4.) Proprietary and Confidential Information shall include all information designated as Proprietary and Confidential by MAX EM including without limitation confidential financial information, confidential competitive information, trade secrets, or any other proprietary and confidential information of MAX EM including, but not limited to, information regarding the design, testing, construction or manufacturing processes of any MAX EM product, information regarding the materials used in the product, or information relating to the composition of materials used in the product.

5.) Confidential Information will not be deemed to include information which:

(a) at the time of disclosure to Therm-O-Disc is generally available to the public or thereafter, without any fault of Therm-O-Disc, becomes generally available to the public by publication or otherwise;

(b) was in the possession of Therm-O-Disc prior to the time of disclosure to Therm-O-Disc or could have been obtained by Therm-O-Disc based on information in the possession of Therm-O-Disc at the time of disclosure;

(c) was independently made known to Therm-O-Disc by a third party not under any obligation or secrecy of confidentiality to MAX EM or

(d) is specifically released to Therm-O-Disc by MAX EM in a written instrument to the extent and for the purposes set forth in such instrument.

8-22-97-85521

Reference TPP1001

T-O-D FORM 1548 (Page 2 of 3)

EXHIBIT D

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6.) If Therm-O-Disc is compelled by legal processes to disclose any MAX EM FLUID SENSOR information, Therm-O-Disc will use its best efforts to obtain a protective order for such documents in accordance with the terms of this Agreement and will give MAX EM as much advance notice as possible and, allow MAX EM the opportunity to intervene in such action, if necessary, and obtain an appropriate confidentiality agreement or protective order.

7.) This Agreement constitutes the entire agreement between MAX EM and Therm-O-Disc with respect to the Proprietary and Confidential Information of MAX EM FLUID SENSOR.

8.) This Agreement may not be changed orally, but only in writing, signed by both MAX EM and Therm-O-Disc.

9.) This agreement shall terminate within 4 years after the completion of the project described in section 3b.

10.) The parties to this agreement represent and warrant that the individuals signing this agreement on their behalf have authority to do so.

11.) This Agreement shall be governed and construed in accordance with the laws of the state of Ohio.

AGREED TO AND ACCEPTED:

RECIPIENT J. MATEK
By MAX EM ENGINEERING
Name JOSEF MATEK
Title OWNER
Date 12.5.97

THERM-O-DISC, INC.
By [Signature]
Name BARBARA S. DENIS
Title VP QUALITY & TECHNOLOGY
Date 12/15/97

B-22-97-65521

Reference TPP1801

T-O-D FORM 1848 (Page 3 of 3)

EXHIBIT D

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93-00005

EXHIBIT C

MAX EM ENGINEERING
Electronic • Mechanical
Product Development

12/5/97

Mr. Bernd Zimmermann
R & D Engineer
Therm-O-Disc
1320 S. Main Street
Mansfield, Ohio 44907

Dear Bernd,

Thank you for your call yesterday.

As we discussed, I am sending you a sample of a piece of the probe, a copy of the claims that have been approved in our patent and an electrical schematics of the present prototype.

The piece of the probe that I sent you was cut from a 12 inch probe. The sensing element is the silvery alloy. Presently, it is 65 mil wide and 1 mil thick. The probe is made of one layer with Copper traces that were etched. A strip of the alloy was soldered to the tip of the Copper traces and a Maylar layer was attached with adhesive on top. Presently the probe is made by lamination. The probe can be made by vacuum deposition, screen printing or using a mold or by a production method that combine all of those methods.

I hope that this is the information that you asked for. If you have any question, please call me. In the meantime, I wish you A VERY HAPPY HOLIDAYS.

Very Truly Yours,

Josef Maatuk, Ph.D., P.E.

EXHIBIT D

MAX EM ENGINEERING
Pro-Active Products
Electronic • Mechanical

2/22/98

Mr. Bernd Zimmermann
R & D Engineer
Therm-O-Disc
1320 S. Main Street
Mansfield, Ohio 44907

Dear Bernd,

Thank you for your help in setting the meeting with your company and your interest in our multi-function sensor. I and my associates look forward to working with you while your company is using due diligence in evaluating our technology.

Per our discussion, I am sending you two things. First, an infringement search that was conducted on my behalf which shows that some of the patents and the literature uses similar words to some of my claims but if you look at those technology through the two requirements of multi-functionality and self-calibration or no calibration for accurate reading using software methods instead of expensive production methods, you will see that none of those technologies have all the features that our technology has. For example, you can use fiber-optic technology to eliminate EMI. With our technology, we eliminate the effect of EMI either with low-cost hardware (the heater has a low impedance and you can use a low-cost capacitor to take the EMI effects. Since in our design, the EMI is a common mode it can be minimized by using differential reading.

The second thing that I am sending you is the test results that we conducted to improve the signal to noise ratio by using different size heater as well as spreading the heat so that the taps can be further apart and thus use less traces. In those tests, we used the Keithly data acquisition that has a response of 1 second. We have conducted a lot of experiments but I will send you the results of only three of them.

EXHIBIT E

MAX EM ENGINEERING
Pro-Active Products
Electronic • Mechanical

3/26/98

Mr. Bernd Zimmermann
R & D Engineer
Therm-O-Disc
1320 S. Main Street
Mansfield, Ohio 44907

Dear Bernd,
Thanks a lot for your call today and I look forward to your test matrix and parameters that will be faxed tomorrow.

I have briefly discussed your requirements for a 6-inch probe with 5 wires. One possible way of doing this, is to use un-even spacing between the taps (instead of equal spacing). Maybe read the top and bottom 0.75 inch as just wanting to know if the fuel is within this range while the other 4.5 inches to be read with accuracy of 0.25 inches for any point within the range of those 4.5 inches.

Let me know your thoughts on the accuracy of the readings that you want for the 6-inch probe.

I look forward to moving forward with you on the soaking test and the EMI testing. I will also keep you posted on any other licensing that we come close to signing it.

Very Truly Yours,

Josef Maatuk, Ph.D., P.E.,

P.O. Box 351055 • Los Angeles, California 90035 • (310) 552-1434

EXHIBIT F

MAX EM ENGINEERING
Pro-Active Products
Electronic • Mechanical

4/19/98

Dr. Prasad S. Khadkikar
Manager, Advanced Technology
THERMODISC, Inc.
1320 S. Main St.
Mansfield, Ohio 44907

Dear Dr. Khadkikar,

Thank you for your time on the phone last Thursday discussing your interest in our multi-function liquid sensor.

In this letter, I will describe the two subjects that we discussed on the phone. First, developing a slightly modified prototype. Second, start putting on papers our business expectations and ideas for licensing our multi-function liquid sensor to Thermodisc.

We propose to develop a slightly modified sensor that will use the existing electronic hardware together with a probe that will be specified by Max Em and supplied by Thermodisc. Max Em will adapt the existing level sensing Software to display three things for fuels :

- 1) Liquid Level for a set of fuels. The set should not exceed 7 types of fuels.
- 2) a measure of the fluid or specifically fuel temperature
- 3) a measure of the thermal properties of the fuel that is expected to represent the kind of fuel.

We propose that Thermodisc will select the method of production and the material for the probe that will easy and cheap to produce while getting more of the heat to the liquid (in comparison to the existing Kapton as a material and lamination as the method of production).

the fuel tank and the fifth Copper trace, 1 inch above the bottom of the fuel tank. Additionally, in order to use the connection of The Copper traces to the heater as a thermocouple joints, additional work needs to be done. Once such work is completed, most likely, we will be able to get the fuel level reading with 5 taps whereby the first tap start about 1 inch below the top of the fuel tank and the last (fifth) tap is 1 inch above the bottom of the tank.

These are the important points that I wanted to run by you. After your review, if you have any question, feel free to contact me.

Very Truly Yours,

Josef Maatuk, Ph.D., P.E.

P.O. Box 351055 • Los Angeles . California 90035 • (310) 652-1434

EXHIBIT G

MAX EM ENGINEERING
Pro-Active Products
Electronic • Mechanical

5/17/98

Dr. Prasad S. Khadkikar
Manager, Advanced Technology
THERMODISC, Inc.
1320 S. Main St.
Mansfield, Ohio 44907

Dear Dr. Khadkikar,

Thank you for your call last Wednesday telling me about you sending me a copy of your marketing plan to capture your share of the automotive liquids sensor market. I look forward to reviewing and discussing those plans with you.

After our phone discussion, I had a couple of thoughts that I wanted to share with you. First, using our strip can be cost effectively used as a thermal switch as well as a health monitor of the product that the switch protects. For example, it will be possible not only to trip a switch or give a command to a power but also to monitor how fast the heating occur. By using strips with a digital address, it will be possible to use a single electronic hardware that will monitor the different digital addresses. Moreover, the ASIC for the liquid sensor can be used not just for monitoring the liquid parameters but also to monitor the temperature rise of the locations of the strips that are used as thermal switches.

Second, it is very highly likely that the automotive OEM might agree to use a single technology for a new automotive liquid sensor but will require at least 2 or three suppliers for those sensors and will not agree for a single supplier.

These are the two thoughts that I wanted to share with you. I will be leaving Los Angeles early Tuesday morning to visit the SENSORS show and meet again with the potential licensee in the San Francisco area.

Thank you again for your call. I look forward to your marketing plan and discussing it with you.

Very Truly Yours,

Josef Maatuk, Ph.D., P.E.

P.O. Box 351055 • Los Angeles, California 90035 • (310) 652-1434

12-43

118-000001

We also suggest that Thermodisc develop at least three probes that will allow the variations of the high, low and medium values of some of the probe parameters. At least Thermodisc should consider the vacuum deposition together with lamination as possible methods of productions.

Based on the method of production and material of the probe that Thermodisc select and the probe that you provide, we expect a proper signal to noise ratio. Since we really do not know how good the signal to noise ratio will be, we can only do our best for giving you a prototype that you can use in a lab to demonstrate that is can determine continuously liquid level, temperature and the kind of fuel.

The development cost for our efforts will be \$ 30,000 and it will take us 10 to 12 weeks to complete it, assuming that Thermodisc will supply the probe within 2 to 3 weeks after we give you the specifications. The first payment will be \$ 18,000 at start of work and the \$ 12,000 will be paid after meeting some defined milestones but 2 weeks before delivery of the 3 function prototype.

Once you demonstrate the proof of concept in a lab environment, you will be able to adapt it to different designs like 5-wires of Walbro which will probably be a limited application as well as the generic application. To make the 12 wires design measure the 3 fluid parameters with 5 wires only will probably require additional developmental effort of \$ 50,000 and 4 to 6 months time.

The second point of this letter will describe our ideas on a licensing agreement between Thermodisc and Max Em. For our business relationship to work, Thermodisc will need to make three commitments. First, allocate resources to capture a share of an automotive market within a given time. Second, Thermodisc allocates resources to productizing the probe and develop the ASIC for our multi-function liquid sensor. Third, allocate funding for Max Em developmental efforts.

Concerning the marketing efforts and market penetration, we would like to work with companies that can capture 15 to 20 percent share of the market so that we give those companies exclusive rights. For companies that capture smaller market share we intend to offer our technology on a non-exclusive basis. In the present automotive market, our multi-function technology can be used for fuel, engine oil, coolant and brake fluids. In the future automotive systems that I anticipate them to be pro-active (instead of present automotive systems that use reactive feedback), our sensor can be used for other purposes too.

We strongly believe that the best way to penetrate the automotive market, will be in the fuel sensing market. Giving you a proof of concept for fuel level, temperature and kind of fuel is doable relatively quickly. Giving you a proof of

**UNITED STATES DISTRICT COURT, CENTRAL DISTRICT OF CALIFORNIA
CIVIL COVER SHEET**

I. (a) PLAINTIFFS (Check box if you are representing yourself ☒)

Josef Maatuk

DEFENDANTS (Check box if you are representing yourself ☐)

EMERSON ELECTRIC, INC., THERM-O-DISC, BERND ZIMMERMAN, PRASAD KHADKIKAR, AND DOES 1-10, INCLUSIVE

(b) County of Residence of First Listed Plaintiff Los Angeles

(EXCEPT IN U.S. PLAINTIFF CASES)

County of Residence of First Listed Defendant _____

(IN U.S. PLAINTIFF CASES ONLY)

(c) Attorneys (Firm Name, Address and Telephone Number) If you are representing yourself, provide the same information.

Josef Maatuk
1607 S. Sherbourne Dr.
Los Angeles, CA 90035

Attorneys (Firm Name, Address and Telephone Number) If you are representing yourself, provide the same information.

II. BASIS OF JURISDICTION (Place an X in one box only.)

- ☐ 1. U.S. Government Plaintiff
- ☐ 2. U.S. Government Defendant
- ☐ 3. Federal Question (U.S. Government Not a Party)
- ☒ 4. Diversity (Indicate Citizenship of Parties in Item III)

III. CITIZENSHIP OF PRINCIPAL PARTIES—For Diversity Cases Only
(Place an X in one box for plaintiff and one for defendant)

- | | | | | | |
|---|---|---------------------------------------|---|--------------------------------|--------------------------------|
| Citizen of This State | PTF <input checked="" type="checkbox"/> 1 | DEF <input type="checkbox"/> 1 | Incorporated or Principal Place of Business in This State | PTF <input type="checkbox"/> 4 | DEF <input type="checkbox"/> 4 |
| Citizen of Another State | <input type="checkbox"/> 2 | <input checked="" type="checkbox"/> 2 | Incorporated and Principal Place of Business in Another State | <input type="checkbox"/> 5 | <input type="checkbox"/> 5 |
| Citizen or Subject of a Foreign Country | <input type="checkbox"/> 3 | <input type="checkbox"/> 3 | Foreign Nation | <input type="checkbox"/> 6 | <input type="checkbox"/> 6 |

IV. ORIGIN (Place an X in one box only.)

- ☒ 1. Original Proceeding
- ☐ 2. Removed from State Court
- ☐ 3. Remanded from Appellate Court
- ☐ 4. Reinstated or Reopened
- ☐ 5. Transferred from Another District (Specify) _____
- ☐ 6. Multidistrict Litigation - Transfer
- ☐ 8. Multidistrict Litigation - Direct File

V. REQUESTED IN COMPLAINT: JURY DEMAND: ☐ Yes ☒ No (Check "Yes" only if demanded in complaint.)**CLASS ACTION under F.R.Cv.P. 23:** ☐ Yes ☒ No **MONEY DEMANDED IN COMPLAINT:** \$ 500,000**VI. CAUSE OF ACTION** (Cite the U.S. Civil Statute under which you are filing and write a brief statement of cause. Do not cite jurisdictional statutes unless diversity.)

35 USC § 256, CORRECTION OF INVENTORSHIP, MISAPPROPRIATION OF TRADE SECRET, UNJUST ENRICHMENT

VII. NATURE OF SUIT (Place an X in one box only.)

OTHER STATUTES	CONTRACT	REAL PROPERTY CONT.	IMMIGRATION	PRISONER PETITIONS	PROPERTY RIGHTS
<input type="checkbox"/> 375 False Claims Act	<input type="checkbox"/> 110 Insurance	<input type="checkbox"/> 240 Torts to Land	<input type="checkbox"/> 462 Naturalization Application	Habeas Corpus:	<input type="checkbox"/> 820 Copyrights
<input type="checkbox"/> 376 Qui Tam (31 USC 3729(a))	<input type="checkbox"/> 120 Marine	<input type="checkbox"/> 245 Tort Product Liability	<input type="checkbox"/> 465 Other Immigration Actions	<input type="checkbox"/> 463 Alien Detainee	<input type="checkbox"/> 830 Patent
<input type="checkbox"/> 400 State Reapportionment	<input type="checkbox"/> 130 Miller Act	<input type="checkbox"/> 290 All Other Real Property	TORTS	<input type="checkbox"/> 510 Motions to Vacate Sentence	<input type="checkbox"/> 840 Trademark
<input type="checkbox"/> 410 Antitrust	<input type="checkbox"/> 140 Negotiable Instrument	TORTS	PERSONAL PROPERTY	<input type="checkbox"/> 530 General	SOCIAL SECURITY
<input type="checkbox"/> 430 Banks and Banking	<input type="checkbox"/> 150 Recovery of Overpayment & Enforcement of Judgment	PERSONAL INJURY	<input type="checkbox"/> 370 Other Fraud	<input type="checkbox"/> 535 Death Penalty	<input type="checkbox"/> 861 HIA (1395ff)
<input type="checkbox"/> 450 Commerce/ICC Rates/Etc.	<input type="checkbox"/> 151 Medicare Act	<input type="checkbox"/> 310 Airplane	<input type="checkbox"/> 371 Truth in Lending	Other:	<input type="checkbox"/> 862 Black Lung (923)
<input type="checkbox"/> 460 Deportation	<input type="checkbox"/> 152 Recovery of Defaulted Student Loan (Excl. Vet.)	<input type="checkbox"/> 315 Airplane Product Liability	<input type="checkbox"/> 380 Other Personal Property Damage	<input type="checkbox"/> 540 Mandamus/Other	<input type="checkbox"/> 863 DIWC/DIWW (405 (g))
<input type="checkbox"/> 470 Racketeer Influenced & Corrupt Org.	<input type="checkbox"/> 153 Recovery of Overpayment of Vet. Benefits	<input type="checkbox"/> 320 Assault, Libel & Slander	<input type="checkbox"/> 385 Property Damage Product Liability	<input type="checkbox"/> 550 Civil Rights	<input type="checkbox"/> 864 SSID Title XVI
<input type="checkbox"/> 480 Consumer Credit	<input type="checkbox"/> 160 Stockholders' Suits	<input type="checkbox"/> 330 Fed. Employers' Liability	BANKRUPTCY	<input type="checkbox"/> 555 Prison Condition	<input type="checkbox"/> 865 RSI (405 (g))
<input type="checkbox"/> 490 Cable/Sat TV	<input type="checkbox"/> 190 Other Contract	<input type="checkbox"/> 340 Marine	<input type="checkbox"/> 422 Appeal 28 USC 158	FORFEITURE/PENALTY	FEDERAL TAX SUITS
<input type="checkbox"/> 850 Securities/Commodities/Exchange	<input type="checkbox"/> 195 Contract Product Liability	<input type="checkbox"/> 345 Marine Product Liability	<input type="checkbox"/> 423 Withdrawal 28 USC 157	<input type="checkbox"/> 625 Drug Related Seizure of Property 21 USC 881	<input type="checkbox"/> 870 Taxes (U.S. Plaintiff or Defendant)
<input checked="" type="checkbox"/> 890 Other Statutory Actions	<input type="checkbox"/> 196 Franchise	<input type="checkbox"/> 350 Motor Vehicle	CIVIL RIGHTS	<input type="checkbox"/> 690 Other	<input type="checkbox"/> 871 IRS-Third Party 26 USC 7609
<input type="checkbox"/> 891 Agricultural Acts	REAL PROPERTY	<input type="checkbox"/> 355 Motor Vehicle Product Liability	<input type="checkbox"/> 440 Other Civil Rights	LABOR	
<input type="checkbox"/> 893 Environmental Matters	<input type="checkbox"/> 210 Land Condemnation	<input type="checkbox"/> 360 Other Personal Injury	<input type="checkbox"/> 441 Voting	<input type="checkbox"/> 710 Fair Labor Standards Act	
<input type="checkbox"/> 895 Freedom of Info. Act	<input type="checkbox"/> 220 Foreclosure	<input type="checkbox"/> 362 Personal Injury-Med Malpractice	<input type="checkbox"/> 442 Employment	<input type="checkbox"/> 720 Labor/Mgmt. Relations	
<input type="checkbox"/> 896 Arbitration	<input type="checkbox"/> 230 Rent Lease & Ejectment	<input type="checkbox"/> 365 Personal Injury-Product Liability	<input type="checkbox"/> 443 Housing/Accommodations	<input type="checkbox"/> 740 Railway Labor Act	
<input type="checkbox"/> 899 Admin. Procedures Act/Review of Appeal of Agency Decision		<input type="checkbox"/> 367 Health Care/Pharmaceutical Personal Injury Product Liability	<input type="checkbox"/> 445 American with Disabilities-Employment	<input type="checkbox"/> 751 Family and Medical Leave Act	
<input type="checkbox"/> 950 Constitutionality of State Statutes		<input type="checkbox"/> 368 Asbestos Personal Injury Product Liability	<input type="checkbox"/> 446 American with Disabilities-Other	<input type="checkbox"/> 790 Other Labor Litigation	
			<input type="checkbox"/> 448 Education	<input type="checkbox"/> 791 Employee Ret. Inc. Security Act	

FOR OFFICE USE ONLY:

Case Number:

CV-71 (07/16)

CIVIL COVER SHEET

Page 1 of 3

UNITED STATES DISTRICT COURT, CENTRAL DISTRICT OF CALIFORNIA
CIVIL COVER SHEET

VIII. VENUE: Your answers to the questions below will determine the division of the Court to which this case will be initially assigned. This initial assignment is subject to change, in accordance with the Court's General Orders, upon review by the Court of your Complaint or Notice of Removal.

QUESTION A: Was this case removed from state court? <input type="checkbox"/> Yes <input checked="" type="checkbox"/> No If "no," skip to Question B. If "yes," check the box to the right that applies, enter the corresponding division in response to Question E, below, and continue from there.	STATE CASE WAS PENDING IN THE COUNTY OF: <input type="checkbox"/> Los Angeles, Ventura, Santa Barbara, or San Luis Obispo <input type="checkbox"/> Orange <input type="checkbox"/> Riverside or San Bernardino	INITIAL DIVISION IN CACD IS: Western Southern Eastern	
QUESTION B: Is the United States, or one of its agencies or employees, a PLAINTIFF in this action? <input type="checkbox"/> Yes <input checked="" type="checkbox"/> No If "no," skip to Question C. If "yes," answer Question B.1, at right.	B.1. Do 50% or more of the defendants who reside in the district reside in Orange Co.? <i>check one of the boxes to the right</i> → B.2. Do 50% or more of the defendants who reside in the district reside in Riverside and/or San Bernardino Counties? (Consider the two counties together.) <i>check one of the boxes to the right</i> →	<input type="checkbox"/> YES. Your case will initially be assigned to the Southern Division. Enter "Southern" in response to Question E, below, and continue from there. <input type="checkbox"/> NO. Continue to Question B.2. <input type="checkbox"/> YES. Your case will initially be assigned to the Eastern Division. Enter "Eastern" in response to Question E, below, and continue from there. <input type="checkbox"/> NO. Your case will initially be assigned to the Western Division. Enter "Western" in response to Question E, below, and continue from there.	
QUESTION C: Is the United States, or one of its agencies or employees, a DEFENDANT in this action? <input type="checkbox"/> Yes <input checked="" type="checkbox"/> No If "no," skip to Question D. If "yes," answer Question C.1, at right.	C.1. Do 50% or more of the plaintiffs who reside in the district reside in Orange Co.? <i>check one of the boxes to the right</i> → C.2. Do 50% or more of the plaintiffs who reside in the district reside in Riverside and/or San Bernardino Counties? (Consider the two counties together.) <i>check one of the boxes to the right</i> →	<input type="checkbox"/> YES. Your case will initially be assigned to the Southern Division. Enter "Southern" in response to Question E, below, and continue from there. <input type="checkbox"/> NO. Continue to Question C.2. <input type="checkbox"/> YES. Your case will initially be assigned to the Eastern Division. Enter "Eastern" in response to Question E, below, and continue from there. <input type="checkbox"/> NO. Your case will initially be assigned to the Western Division. Enter "Western" in response to Question E, below, and continue from there.	
QUESTION D: Location of plaintiffs and defendants? Indicate the location(s) in which 50% or more of <i>plaintiffs who reside in this district</i> reside. (Check up to two boxes, or leave blank if none of these choices apply.) Indicate the location(s) in which 50% or more of <i>defendants who reside in this district</i> reside. (Check up to two boxes, or leave blank if none of these choices apply.)	A. Orange County	B. Riverside or San Bernardino County	C. Los Angeles, Ventura, Santa Barbara, or San Luis Obispo County
	<input type="checkbox"/>	<input type="checkbox"/>	<input checked="" type="checkbox"/>
	<input type="checkbox"/>	<input type="checkbox"/>	<input type="checkbox"/>
D.1. Is there at least one answer in Column A? <input type="checkbox"/> Yes <input checked="" type="checkbox"/> No If "yes," your case will initially be assigned to the SOUTHERN DIVISION. Enter "Southern" in response to Question E, below, and continue from there. If "no," go to question D2 to the right. →	D.2. Is there at least one answer in Column B? <input type="checkbox"/> Yes <input checked="" type="checkbox"/> No If "yes," your case will initially be assigned to the EASTERN DIVISION. Enter "Eastern" in response to Question E, below. If "no," your case will be assigned to the WESTERN DIVISION. Enter "Western" in response to Question E, below. ↓		
QUESTION E: Initial Division? Enter the initial division determined by Question A, B, C, or D above: →	INITIAL DIVISION IN CACD WESTERN		
QUESTION F: Northern Counties? Do 50% or more of plaintiffs or defendants in this district reside in Ventura, Santa Barbara, or San Luis Obispo counties? <input type="checkbox"/> Yes <input checked="" type="checkbox"/> No			

**UNITED STATES DISTRICT COURT, CENTRAL DISTRICT OF CALIFORNIA
CIVIL COVER SHEET**

IX(a). IDENTICAL CASES: Has this action been previously filed in this court?

☒ NO

☐ YES

If yes, list case number(s): _____

IX(b). RELATED CASES: Is this case related (as defined below) to any civil or criminal case(s) previously filed in this court?

☒ NO

☐ YES

If yes, list case number(s): _____

Civil cases are related when they (check all that apply):

- ☐ A. Arise from the same or a closely related transaction, happening, or event;
- ☐ B. Call for determination of the same or substantially related or similar questions of law and fact; or
- ☐ C. For other reasons would entail substantial duplication of labor if heard by different judges.

Note: That cases may involve the same patent, trademark, or copyright is not, in itself, sufficient to deem cases related.

A civil forfeiture case and a criminal case are related when they (check all that apply):

- ☐ A. Arise from the same or a closely related transaction, happening, or event;
- ☐ B. Call for determination of the same or substantially related or similar questions of law and fact; or
- ☐ C. Involve one or more defendants from the criminal case in common and would entail substantial duplication of labor if heard by different judges.

X. SIGNATURE OF ATTORNEY

(OR SELF-REPRESENTED LITIGANT):

J. MARK

DATE: 8.17.2016

Notice to Counsel/Parties: The submission of this Civil Cover Sheet is required by Local Rule 3-1. This Form CV-71 and the information contained herein neither replaces nor supplements the filing and service of pleadings or other papers as required by law, except as provided by local rules of court. For more detailed instructions, see separate instruction sheet (CV-071A).

Key to Statistical codes relating to Social Security Cases:

Nature of Suit Code	Abbreviation	Substantive Statement of Cause of Action
861	HIA	All claims for health insurance benefits (Medicare) under Title 18, Part A, of the Social Security Act, as amended. Also, include claims by hospitals, skilled nursing facilities, etc., for certification as providers of services under the program. (42 U.S.C. 1935FF(b))
862	BL	All claims for "Black Lung" benefits under Title 4, Part B, of the Federal Coal Mine Health and Safety Act of 1969. (30 U.S.C. 923)
863	DIWC	All claims filed by insured workers for disability insurance benefits under Title 2 of the Social Security Act, as amended; plus all claims filed for child's insurance benefits based on disability. (42 U.S.C. 405 (g))
863	DIWW	All claims filed for widows or widowers insurance benefits based on disability under Title 2 of the Social Security Act, as amended. (42 U.S.C. 405 (g))
864	SSID	All claims for supplemental security income payments based upon disability filed under Title 16 of the Social Security Act, as amended.
865	RSI	All claims for retirement (old age) and survivors benefits under Title 2 of the Social Security Act, as amended. (42 U.S.C. 405 (g))